Lomonosov Moscow State University
Business School

Global Limits of Economic Growth

Lomonosov Moscow State University,
Inter-Departmental Course, 2024-2025, Spring Fall

Course Reader:

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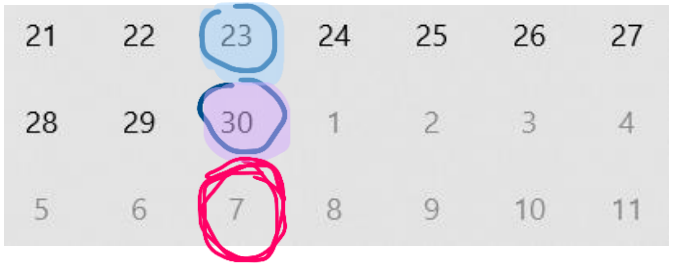
Requirements to Pass the Course

1) No less than 50% of sessions are attended (6 out of 12)

2) There are no less than 60% of points for **the final course test**
   - **May, 7th (Wednesday)**
   - Online in Moodle
   - You'll find your login\password information at your personal accounts in advance



3) Individual Project should be delivered in class on April, 30th

Write the Topic of your individual project in a file

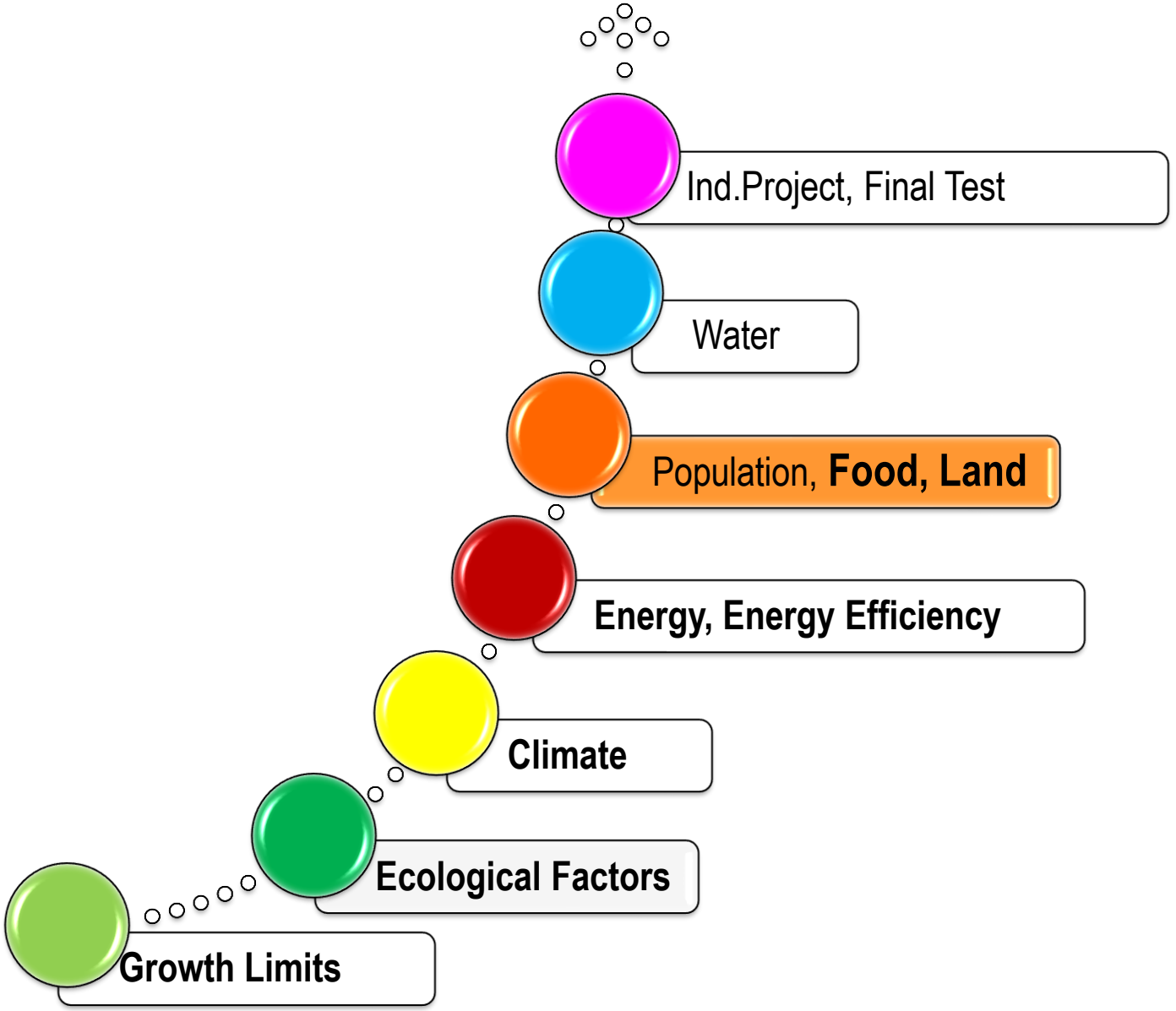
- https://disk.yandex.ru/i/0L_3ptbx-s2yBw

Topics for individual projects

Course «Global Limits of Economic Growth», spring 2025

№	Student's Name & Surname	MSU department	E-mail	Topic selected	Comments of the course teacher
	Example: Aurora Dias	*Geografical Department*	*...@geo.msu.ru*	*Water & electricity as limiting factors for the development of mining industries*	*Accepted*
	Example: Li Yuzhany	*Economic Department*	*...*	*I will participate in the **Climate Simulation Seminar based on the model En-ROADS** (the seminar will take place on one of these dates 30/04 or 14/05 at 13:00-14:30 at MSU BS: the final date will be selected by April, 15)*	*Accepted*
1	Bing Wang	Political Department	c n...u	Energy resource limitations and the glocal economy: challenges and strategies for sustainable growth	***Accepted***
2					
3					
4					

Course Route



Session 10

Food Production & Food Supply

(continuation)

2025

Aims of Session

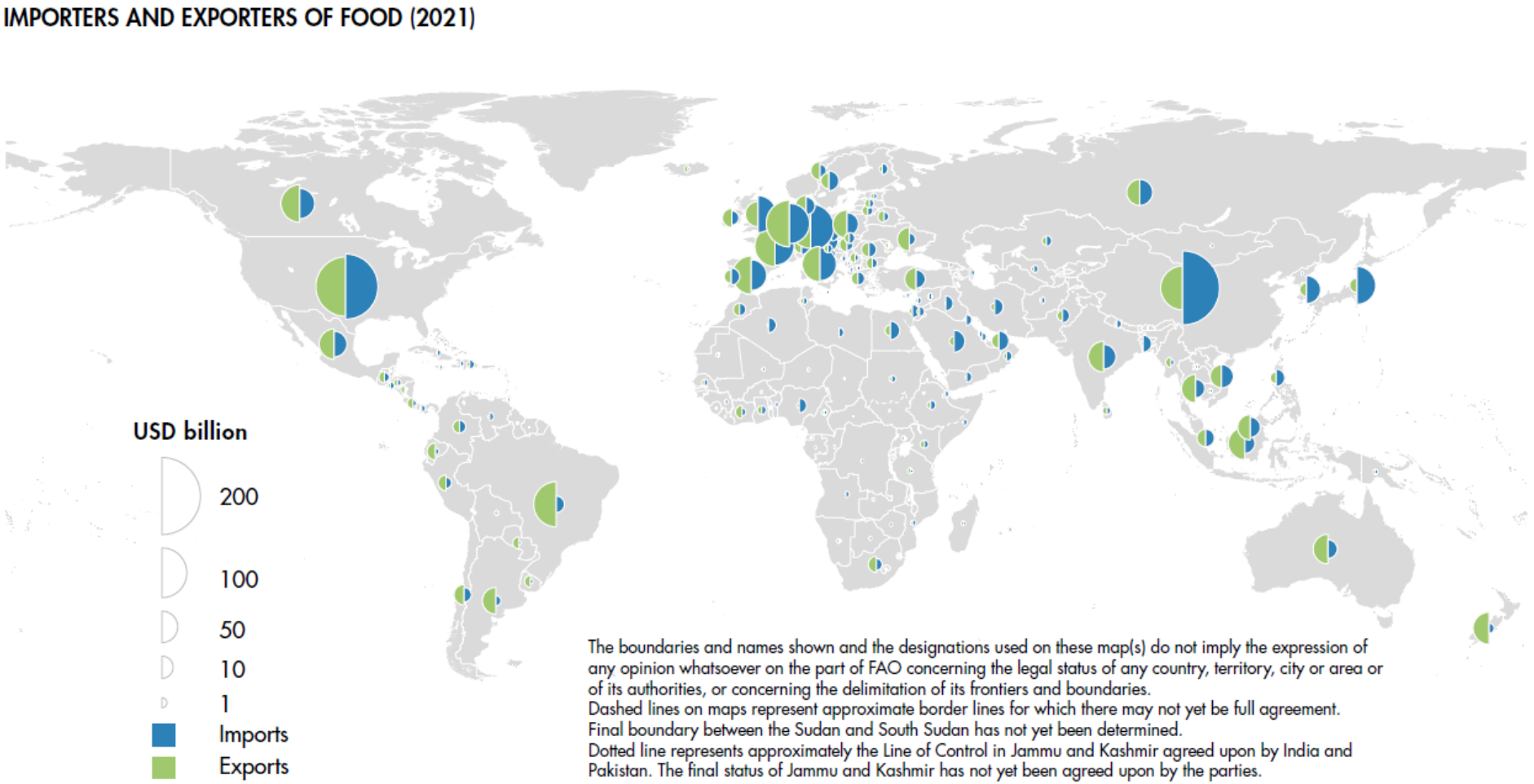
1. To know main limitations that can be produced by food production as for business and national economic growth
2. To work out ways how to overcome these limitations

Session Plan

Food Supply

1. Food Security VS Food Self-Sufficiency
2. Public Policy on Food Security
   - Discussion “pro” & ”con”, basing on FAO article
3. Genetically Modified Food
4. Key Challenges for Food Production Companies

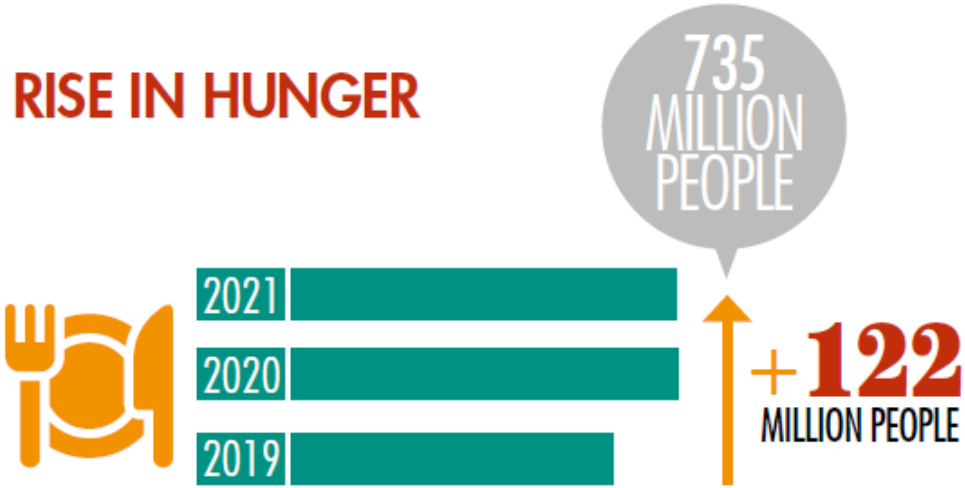
Export & Import of Food



Note: Values for fish exclude trade of aquatic mammals, crocodiles, alligators and caimans, fishmeal, fish oil, ornamental fish, fish for culture and algae.

Source: FAO Statistical Pocketbook 2023

RISE IN HUNGER



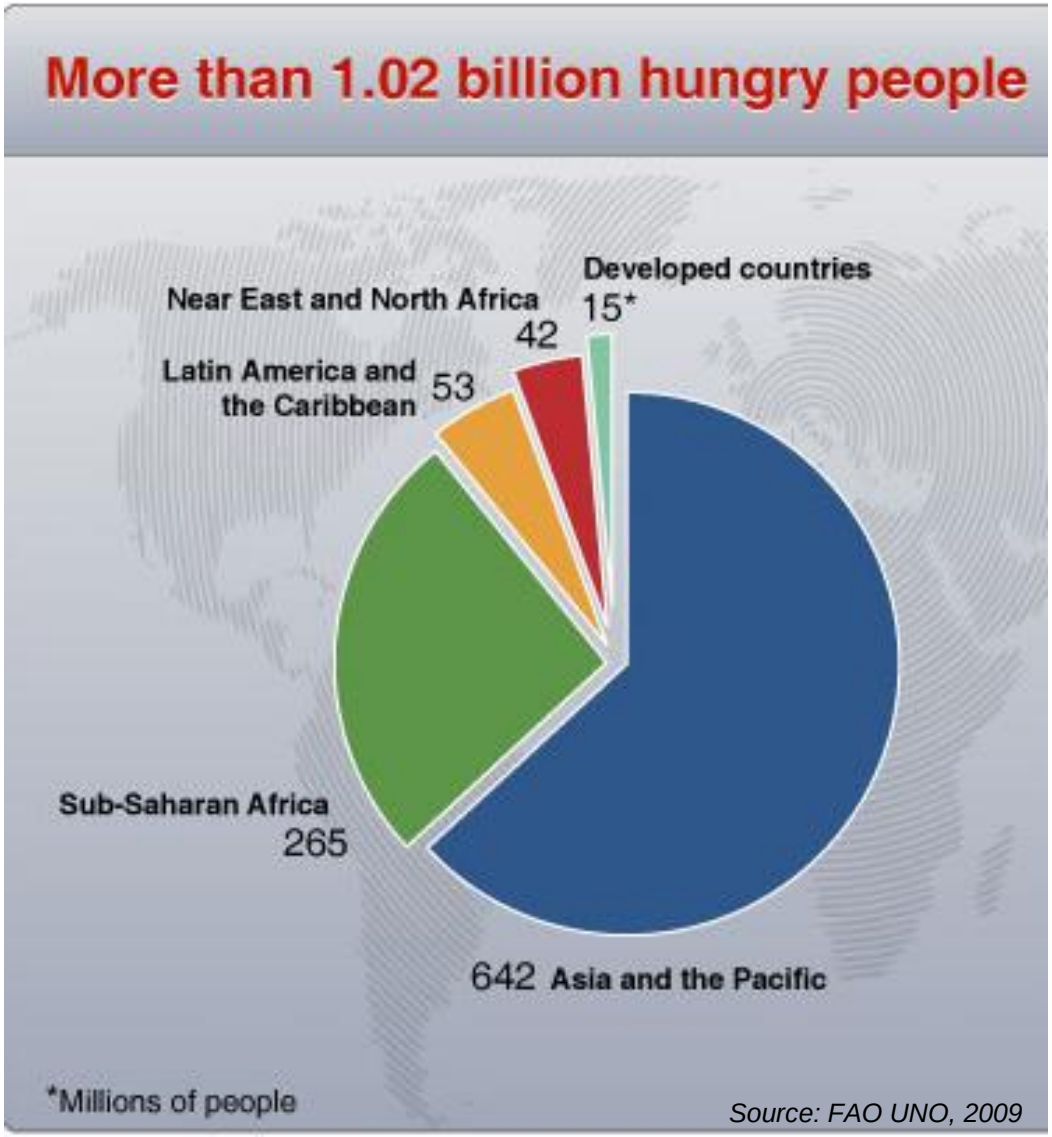
Global hunger, measured by the prevalence of undernourishment, remained relatively unchanged from 2021 to 2022, affecting around 9.2% of the population in 2022, or about 735 million people. This is 122 million more people than in 2019, before the COVID-19 pandemic.

PREVALENCE OF UNDERNOURISHMENT

While most of the undernourished people live in Asia, Africa has the highest prevalence of undernourishment.

Source: FAO Statistical Pocketbook 2023

Where the world's hungry people live



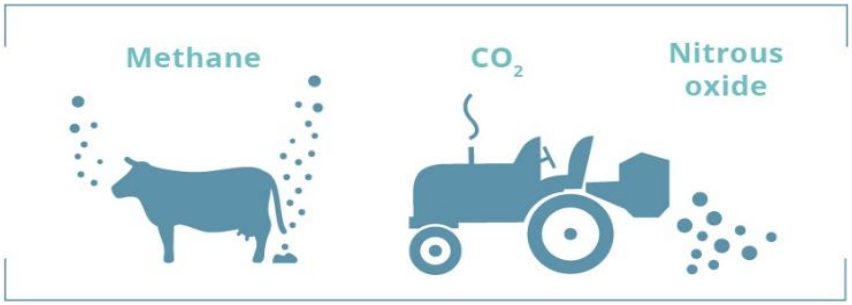
- Hunger causes
  - Poor harvests due to unfavorable climate conditions
  - High domestic food prices
  - Lower incomes
  - Increasing unemployment due to the global economic crisis
  - Unfair distribution of food
  - Limited access to fertile lands due to the status of private property
- The rise in food prices in 2007-08, followed by the financial and economic crisis in 2009, has heightened awareness on poverty and hunger issues around the world.

Climate Change & Food Production

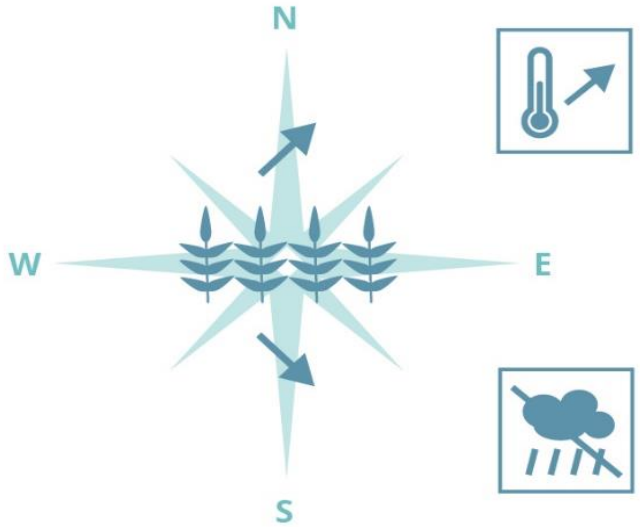
Climate change and agriculture

Agriculture both contributes to climate change and is affected by climate change. The EU needs to reduce its greenhouse-gas emissions from agriculture and adapt its food-production system to cope with climate change. Faced with growing global demand and competition for resources, the EU's food production and consumption need to be seen in a broader context, linking agriculture, energy, and food security.

Agriculture accounts for 10% of the EU's greenhouse-gas emissions.



-24% From 1990 to 2012, greenhouse-gas emissions from agriculture in the EU decreased by 24%.



In southern Europe extreme heat events and reduced precipitation and water availability are expected to reduce crop yields, while the suitability for growing crops may improve in northern Europe.

Climate Change & Food Production

Globally

+14% Between 2001 and 2011, greenhouse-gas emissions from crop and livestock production grew by 14%.

+70% The demand for food is expected to grow by up to 70% in coming decades.

Did you know?

Meat and dairy products have the highest global footprint of carbon, raw materials and water per kilogramme of any food.

Post-farm transport and processing account for only a tiny fraction of the emissions linked to food.

Genetically Modified Food

Who is interested in GM food?

- Big companies
  - GM crops are a way for big companies to take over the livelihoods of small farmers. But 90% of the farmers growing GM crops are comparatively poor.
  - Big firms make a lot of money selling GM seeds. The GM seed market was worth $10.5 billion in 2009, and the crops that grew from that seed were worth over $130 billion.
- National governments (China, India and Brazil) are also developing new GM crops and Charity Foundations.
- Consumers?
  - More food
  - More food resistant to external biological and climate factors
  - Health impacts?
  - Price? Cheaper or more expensive?

There are no scientifically proved facts that GM food affects human health

Long-term Consequences for the Environment and Human Health?

Key Challenges for Food Production Companies

- Standards of food production
  - High quality
- Responsibility
  - People's health
  - Creating certain tradition of nutrition (should be healthy, etc., but not always is) products tastes, consumption, diets
- Adapting to regional cultures in terms of food consumption
- Innovations used have doubtful advantages (GMF, food additives)
- …

The Future of Food Production

- By 2050 there will be another 2.5 billion people on the planet. How to feed them?

- We grow nearly twice as much food as we did just a generation ago, but we use three times as much water from rivers and underground supplies.

How to receive 2 times more food reducing negative impact on the environment produced by the agriculture?

5 steps

- *Not to expand farmland*
- *To get more from existing fields*
- *To use rationally natural resources*
- *To change diet*
  - *Today, only 55% of calories derived from the crop itself fed people in the world; the rest goes to feed livestock (36%) or converted into biofuels and industrial goods (9%).*
- *To reduce waste*
  - *Up to half of the total weight of food is thrown out or deteriorates before people have time to eat it.*

Nearly 1/3 – ½ of the food the world produces is ultimately lost or wasted.

Photo by Foerster/Wikimedia Commons

THE WORLD NEEDS MORE

By 2050 population will grow by approximately 35%

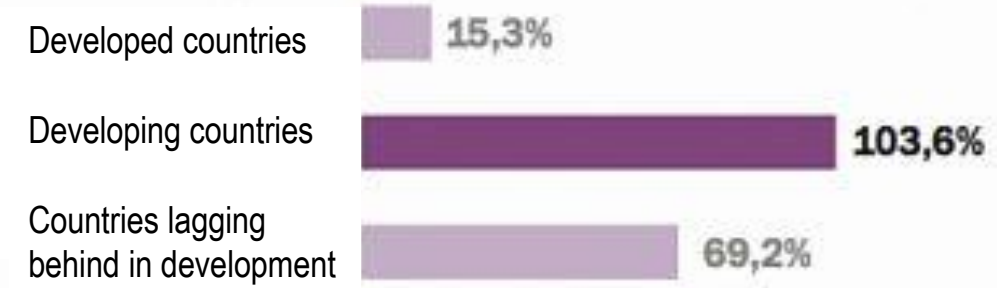
1 bln people

To feed this population the world needs to increase the yields of cereals twice

1 bln tonnes

Why? The growth of agricultural production will have to far exceed population growth, since developing countries are taking a new standard of living when their inhabitants begin to eat more meat.

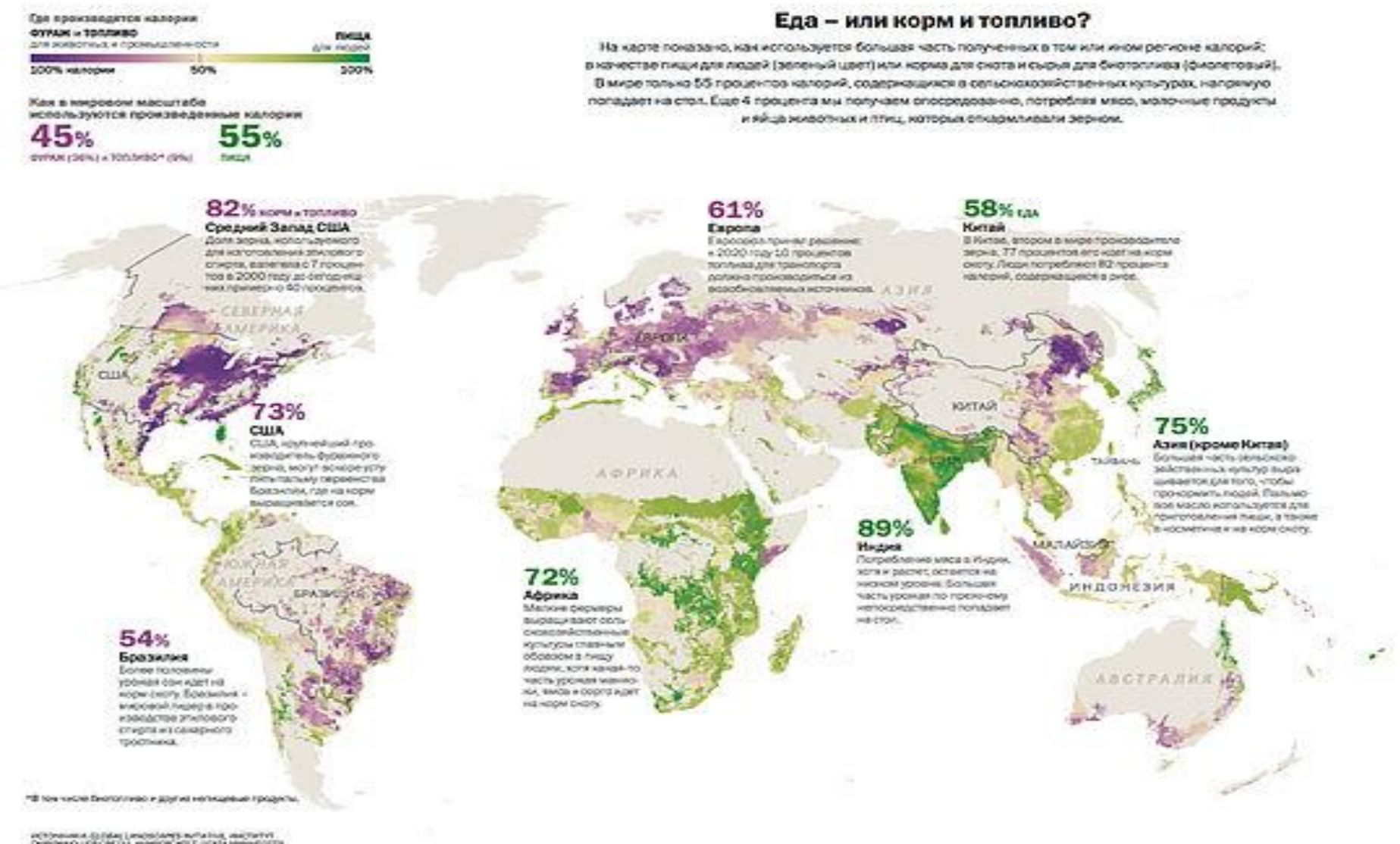
Increase of daily demand for protein foods (per capita by 2050)



ИСТОЧНИК: ДЭВИД ТИЛМАН, УНИВЕРСИТЕТ ШТАТА МИННЕСОТА

The way of using the calories obtained: as food for humans (green) or the livestock feed and raw materials for biofuels (purple).

In the world, only 55% of the calories contained in crops, goes directly to the table.



The Future of Food Production

Algae

Desert greening

Insects

Artificial Meat

Artificial Meet

- In 2013 the cost of the burger with a meatball from the meat grown in the lab was more than $300,000, and now it hardly exceeds $10.
  - The price fell down in 30,000 times in 4 years
- November 2016
  - 1 kg of artificial meat - around **$80**
  - 1 kg of natural beef meat - **$7-8**

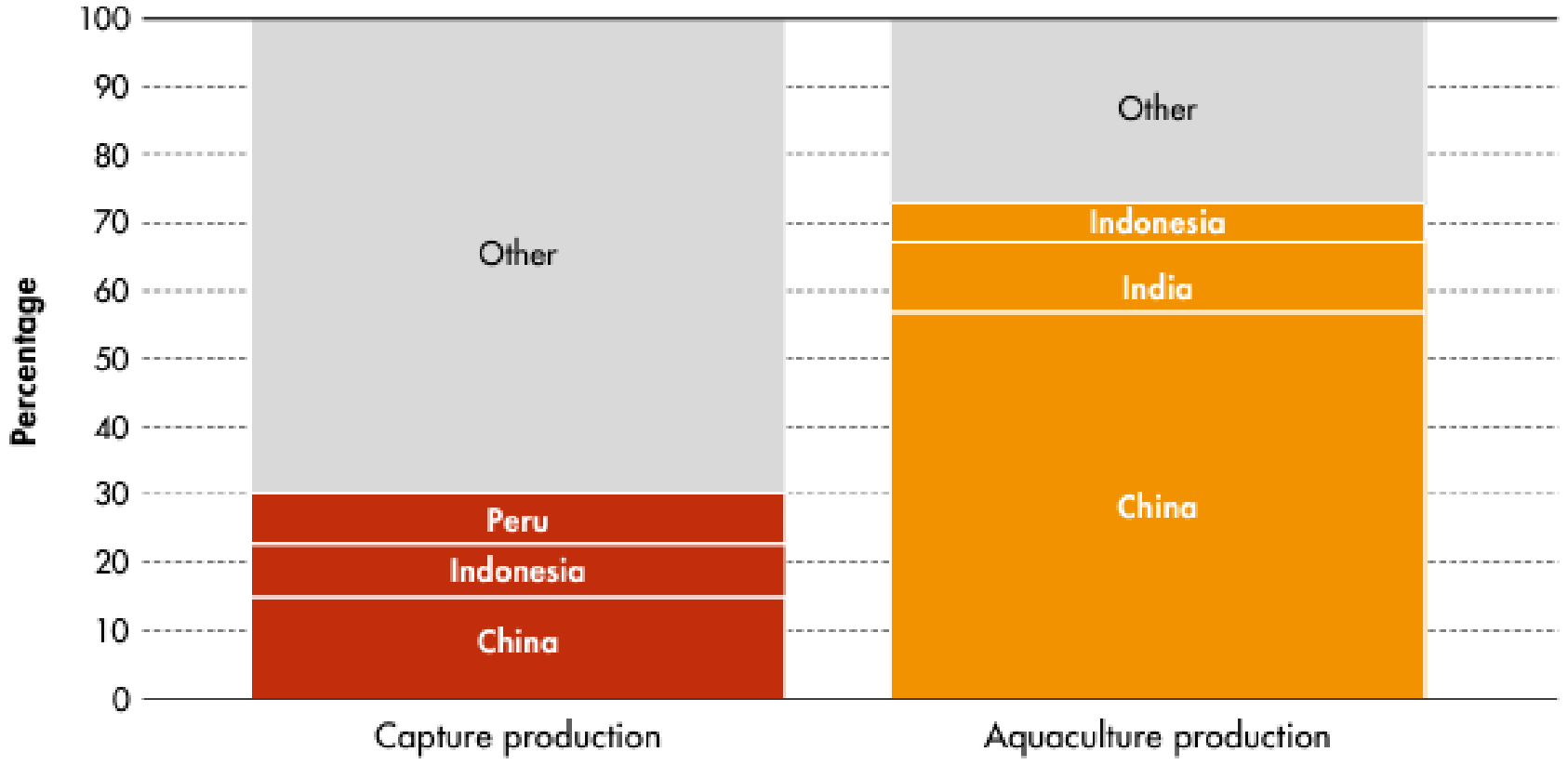
- Why the production of natural meat is harmful to the environment?

- Would the artificial meat save the situation?

https://hightech.fm/2017/02/22/lab_grown_meat

Ocean Potential in Terms of Food

WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION BY MAIN PRODUCERS (2021)

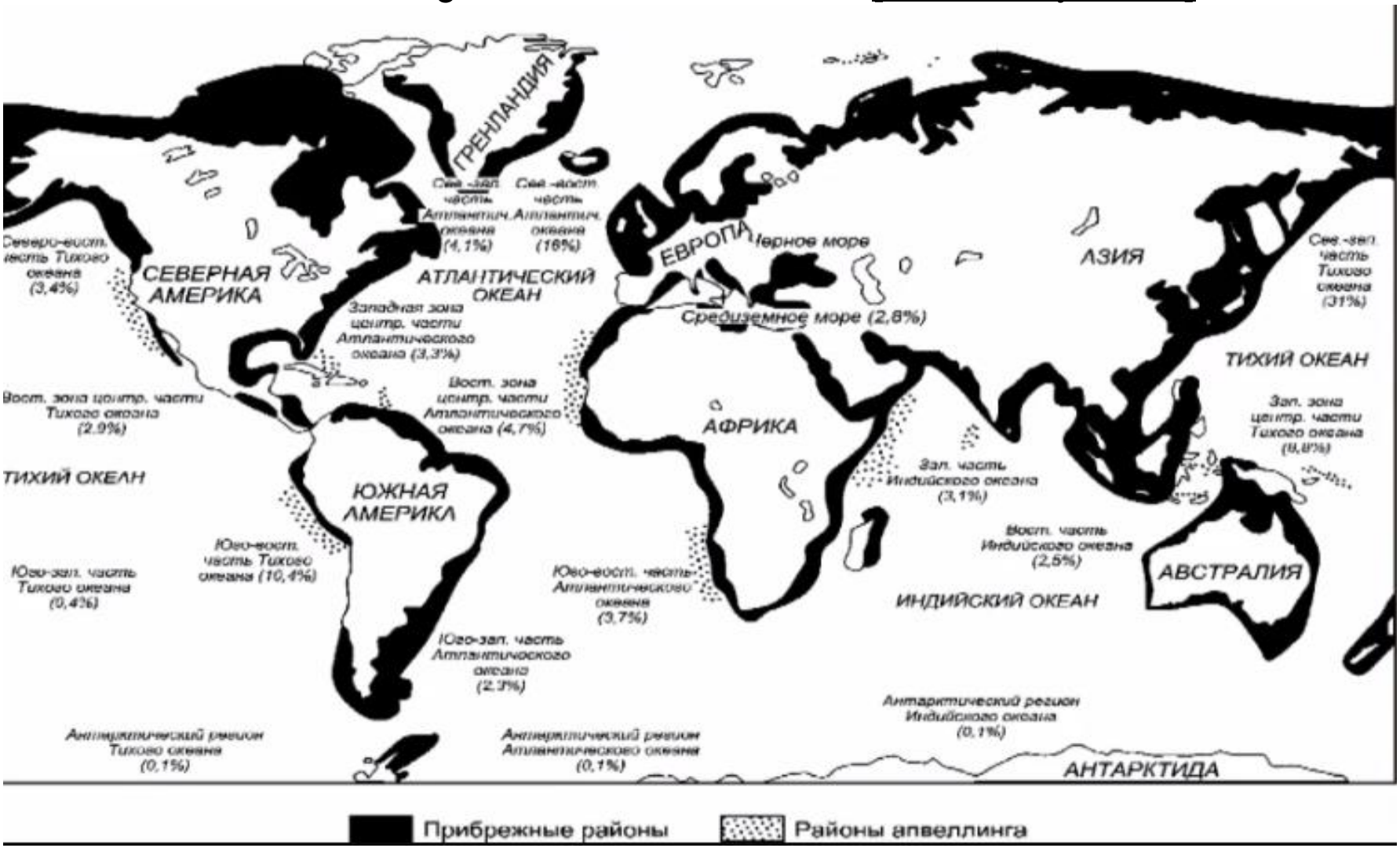


Note: Excludes aquatic mammals, crocodiles, alligators and caimans, pearls and shells, corals, sponges and algae.

Source: FAO. 2023. Fisheries and Aquaculture: Global production by production source Quantity (1950 - 2021). In: *FAO*. Rome. [Cited October 2023]. https://www.fao.org/fishery/statistics-query/en/global_production/global_production_quantity
Download: https://doi.org/10.4060/cc8166en-fig32

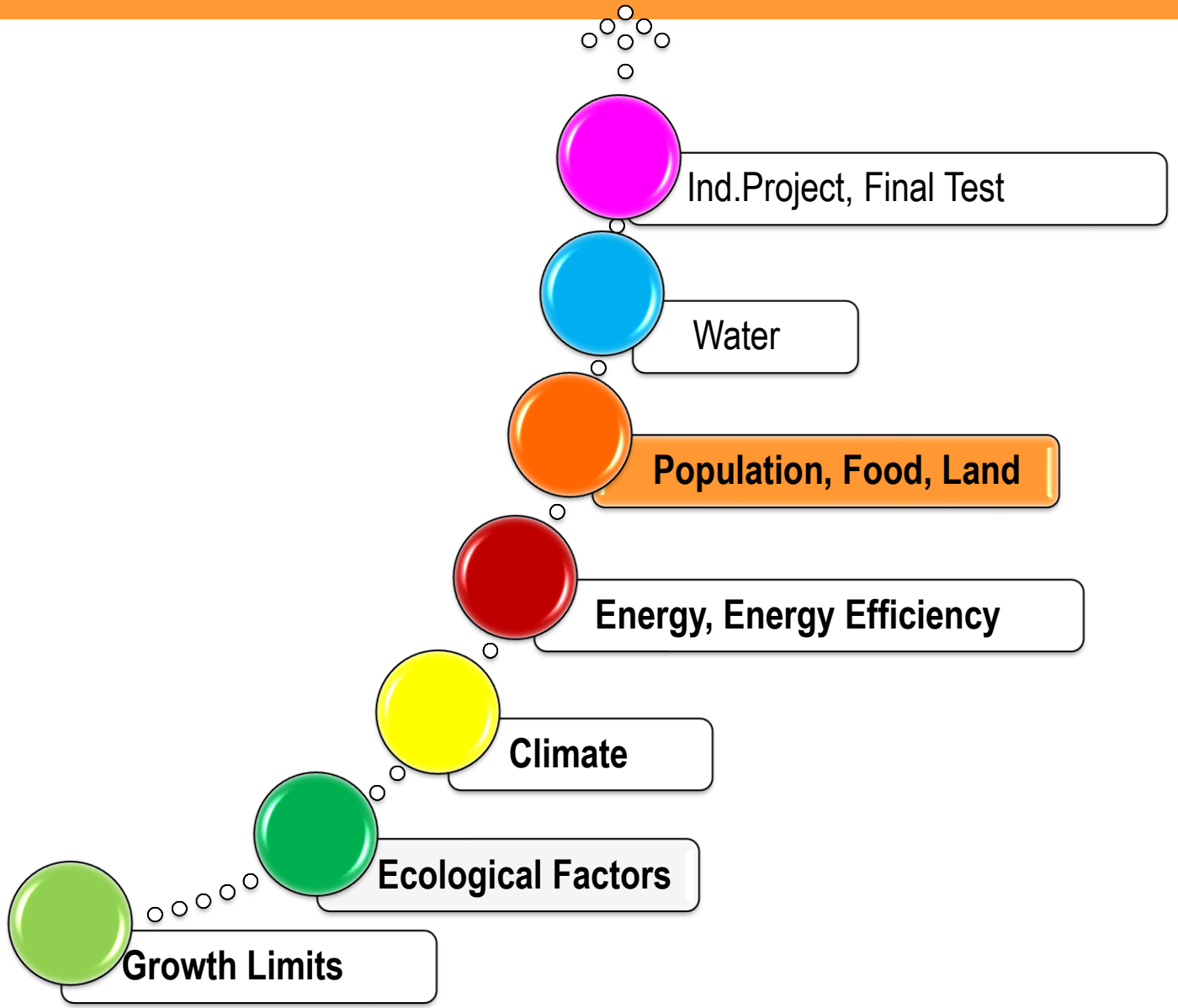
Ocean Potential in Terms of Food

Areas with High Productive Potential [marked by black]



Based on OpenEdu.Ru, “Global Ecological Problems and Sustainable Development” by Marfenin N.N., Popova L.V. , 2017

Course Route



Pre-Reading Assignment

World agriculture: towards 2015/2030

Summary report

LAND, AGRICULTURE

- Read Reading Material for the Session 10 (World Agriculture 2015-2030, p.39-44).

  Think about:
  Is there enough potential cropland for future needs?
  Is land becoming scarcer?
  Is there enough irrigable land for future needs?
  What are the factors that limit the agriculture production?

Session 10

Agriculture and Land Use Issues

2025



Aims

LAND, AGRICULTURE

- **To identify main factors limiting agriculture production using statistical data approach (FAOSTAT, AQUASTAT)**
- **To understand how to overcome these limitations**

Is there enough potential cropland for future needs?
Is land becoming scarcer?
Is there enough irrigable land for future needs?
What are the factors that limit the agriculture production?

Content

1. Agriculture as an Economic Sector
2. How to Feed the Growing Population?
3. Trends in Agriculture
4. Green Revolution
5. Sources of Growth in Crop Production and the Consequences of Green Revolution
   - Agriculture Trends
   - Territorial Strategies in Agricultural Business
6. Land Conflicts

Agriculture as an Economic Sector

- Agriculture is a unique sector of economy
- It's a mix of science, art and skills to manage plants' and animals' growth for human needs
- The basic aim is the growth of this production

- *In many low-income countries agriculture generates over 1/3 of GDP*
- *Half or more of population in Asia and Sub-Saharan Africa are directly involved in agriculture*

Challenges for Farmers

Source: Syngenta Corporate Presentation, 2017

How will the mankind feed 9 bln people in 30 years?

- Is it possible to expand arable land?
- Is it possible to reach this aim by improvement of technology?
- What are side effects of improving agro-technologies?

Based on OpenEdu.Ru, “Global Ecological Problems and Sustainable Development” by Marfenin N.N., Popova L.V. , 2017

How to feed the growing population?

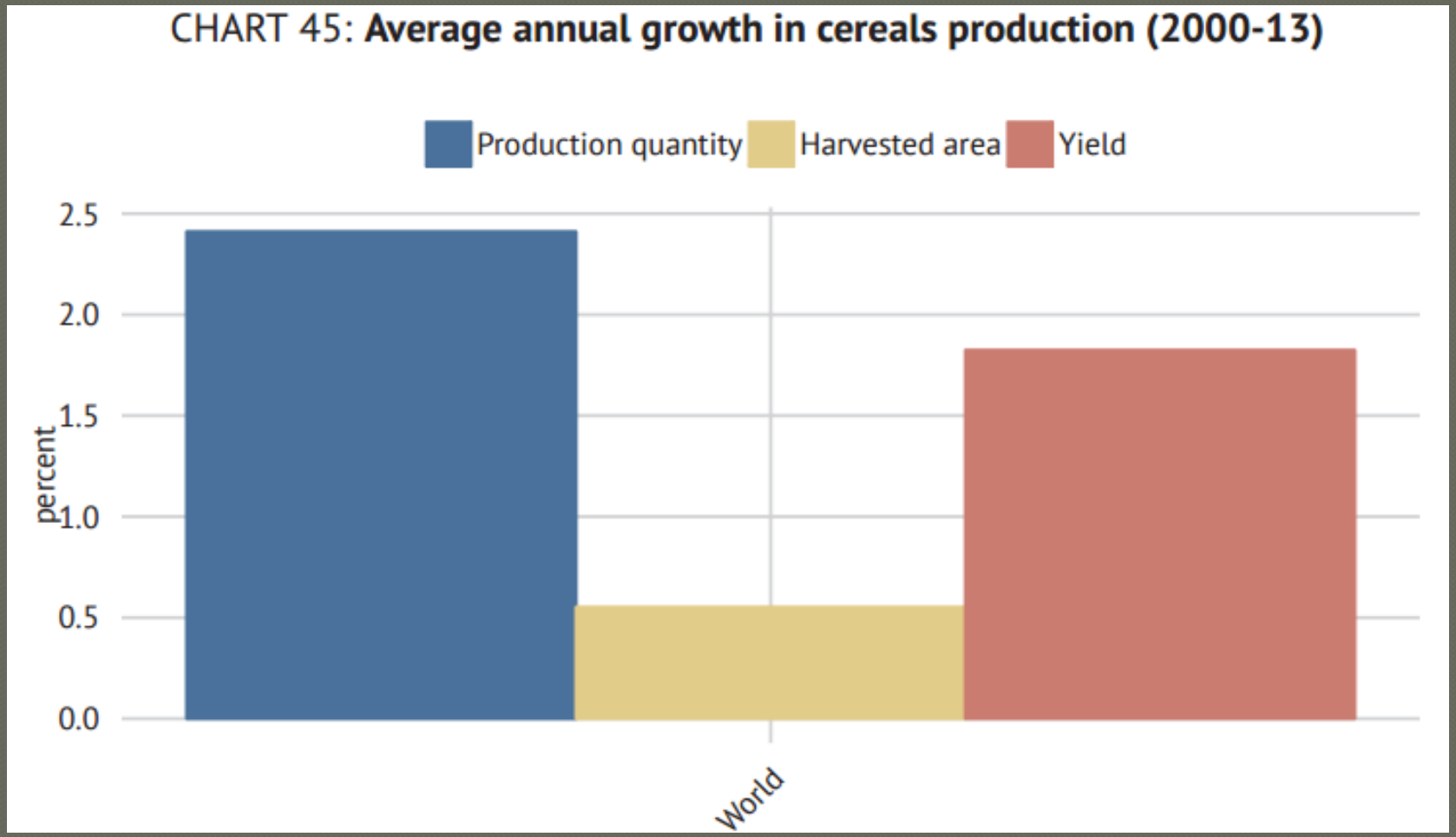
- How many people it will be possible to feed using all existing arable land of 1480 mln ha (2015, FAO), if everywhere we'll use the most efficient agrotechnologies?

Standards of …	**World arable land** (mln ha)		**Arable land/ population** (ha/person)		**Population fed** (mln)
USA	1480	/	0.84	=	1 761
Western Europe	1480	/	0.24	=	6 166
Holland	1480	/	0.06	=	24 666

According to the calculations of the developer of the mathematical model of population growth of the Earth, S.P. Kapitsa, around 2135 there will come a stabilization of the world population with a total population of 12-14 **bln** people. According to UN estimates, stabilization will come about 2100 with a population of 11 bln.

Based on OpenEdu.Ru, "Global Ecological Problems and Sustainable Development" by Marfenin N.N., Popova L.V. , 2017

Trends in Cereals Production



Source: FAO Statistical Pocketbook 2015

Main Trends in World Regional Agriculture

World

	1990	2000	2014
The setting			
Population, total (mln)	5 320.8	6 127.7	7 243.8
Population, rural (mln)	3 033	3 263.4	3 362,5
Govt expenditure on ag (% total outlays)			
Area harvested (mln ha)	1 952	2 061	2 781
Cropping intensity ratio	0.4	0.4	
Water resources (1 000 m^3/person/year)			
Area equipped for irrigation (1 000 ha)			
Area irrigated (% area equipped for irrigation)			
Employment in agriculture (%)	*35.3*	38	*30.7*
Employment in agriculture, female (%)	*9.2*	20.3	*25.2*
Fertilizers, Nitrogen (kg of nutrients per ha)		*64.9*	*85.8*
Fertilizers, Phosphate (kg of nutrients per ha)		*25.9*	*33.2*
Fertilizers, Potash (kg nutrients per ha)		*18.2*	*20.4*
Energy consump, power irrigation (mln kWh)	35 981	130 786	*325 448*
Agr value added per worker (constant US$)			
Hunger dimensions			
Dietary energy supply (kcal/pc/day)	2 597	2 717	2 903
Average dietary energy supply adequacy (%)	113	116	123
Dietary en supp, cereals/roots/tubers (%)	*58*	55	*52*
Prevalence of undernourishment (%)	18.6	15	10.8
GDP per capita (US$, PPP)	8 832	10 241	*13 915*
Domestic food price volatility (index)		3.6	*7.8*
Cereal import dependency ratio (%)	*-0.4*	-0.2	*50.7*
Underweight, children under-5 (%)			
Improved water source (% pop)	78.5	83	*88.7*
Food supply			
Food production value, (2004-2006 mln I$)	1 294 508	1 618 814	*2 246 912*
Agriculture, value added (% GDP)		4	4
Food exports (mln US$)	215 425	276 704	*945 572*
Food imports (mln US$)	237 329	294 271	*966 964*
Production indices (2004-06=100)			
Net food	73	90	*121*
Net crops	72	89	*123*
Cereals	82	92	*123*
Vegetable oils	51	77	*141*
Roots and tubers	74	94	*119*
Fruit and vegetables	58	86	*127*
Sugar	86	93	*132*
Livestock	76	92	*115*
Milk	83	89	*114*
Meat	74	91	*118*
Fish	72	92	*119*
Net trade (mln US$)			
Cereals	-2 447	-4 525	*-6 979*
Fruit and vegetables	-9 430	-7 461	*-5 811*
Meat	-2 574	-682	*5 056*
Dairy products	-663	165	*1 169*
Fish	-3 882	-4 295	*1 257*
Environment			
Forest area (%)	33	32	*32*
Renewable water res withdrawn (% of total)			
Terrestrial protect areas (% total land area)	9	12	*14*
Organic area (% total agricultural area)			*1*
Water withdrawal by agriculture (% of total)			
Biofuel production (thousand kt of oil eq.)	3 987	18 110	*381 064*
Wood pellet prod. (1 000 tonnes)			26 154
Net GHG emissions from AFOLU (CO_2 eq, Mt)	8 075	7 449	*8 165*

Main Trends in World Regional Agriculture

Population growth (% per annum)	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030	2030 to 2050
World	1.6	1.5	1.2	0.9	0.6
Developing countries	1.9	1.7	1.4	1.1	0.7
Industrial countries	0.7	0.7	0.4	0.2	0.0
Transition countries	0.5	0.1	- 0.2	- 0.3	- 0.4

GDP growth (% per annum)	1997-99 to 2015 total	2015 to 2030 total	1997-99 to 2015 per capita	2015 to 2030 per capita
World	3.5	3.8	2.3	2.9
Developing countries	5.1	5.5	3.7	4.4
Industrial countries	3.0	3.0	2.6	2.8
Transition countries	3.7	4.0	4.0	4.3

Growth in demand for agricultural products (% per annum)	1969 to 1999	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030
World	2.2	2.1	2.0	1.6	1.4
Developing countries	3.7	3.7	4.0	2.2	1.7
Industrial countries	1.1	1.0	1.0	0.7	0.6
Transition countries	- 0.2	- 1.7	- 4.4	0.5	0.4

Growth in agricultural production (% per annum)	1969 to 1999	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030
World	2.2	2.1	2.0	1.6	1.3
Developing countries	3.5	3.7	3.9	2.0	1.7
Industrial countries	1.3	1.0	1.4	0.8	0.6
Transition countries	- 0.4	- 1.7	- 4.7	0.6	0.6


Green Revolution

- Green Revolution is a broad agricultural movement
  - **Green Revolution** refers to a series of research, development, and technology transfer initiatives, occurring between the 1940s and the late 1970s, that increased agriculture production around the world, beginning most markedly in the late 1960s using **(1) selection, (2) mechanization, (3) irrigation and the use of (4) fertilizers and (5) chemicals.**
  - The term first used in 1968
- It was not a massive transfer of leading technologies from developed countries to the farmers of developing ones

Green Revolution

- **Norman Ernest Borlaug** (1924-2009), the plant scientist
  - Is a central figure of the crop revolution
  - Received the Nobel prize of 1970 for his advances in plant breeding
    - spectacular success in increasing food production in Latin America, Asia and to certain extent in Africa
  - His aim was to feed over 100 mln population of poor countries and to combat famine and starvation in the world


Green Revolution

- Social and environmental consequences of the Green Revolution
  - saved hundreds of millions of lives
  - displaced smaller farmers facilitating greater corporate control of agriculture
  - encouraged overreliance on chemicals and fertilizers
  - led to soil depletion and erosion
  - introduced large scale GM food that reduced biodiversity

Sources of Growth in Crop Production

- What are the main sources (factors) of growth in crop production?

Sources of Growth in Crop Production

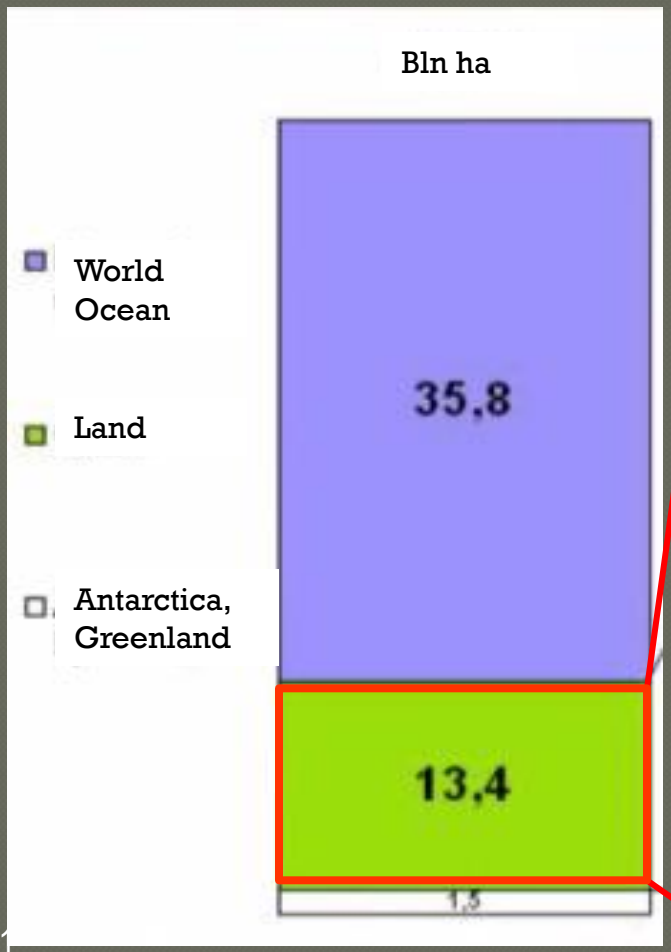
- 3 main sources of growth in crop production:
  1. **Expanding the land area**
  2. **Increasing the frequency with which it is cropped (through irrigation)**
  3. **Boosting yields (through fertilizers, chemicals and mechanization)**

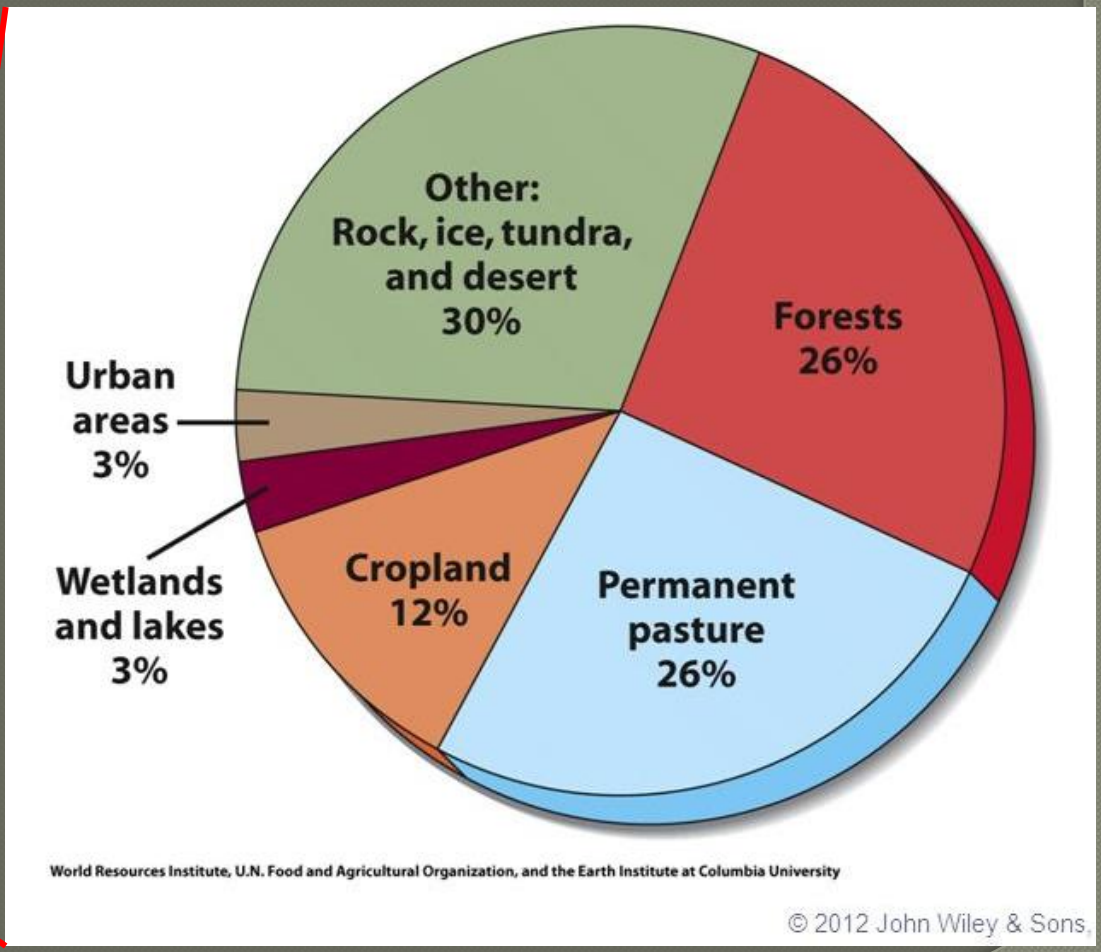
We may be approaching the ceiling of what is possible for all three sources

4. **Selection, creation of GM plants**

1. Land Resources

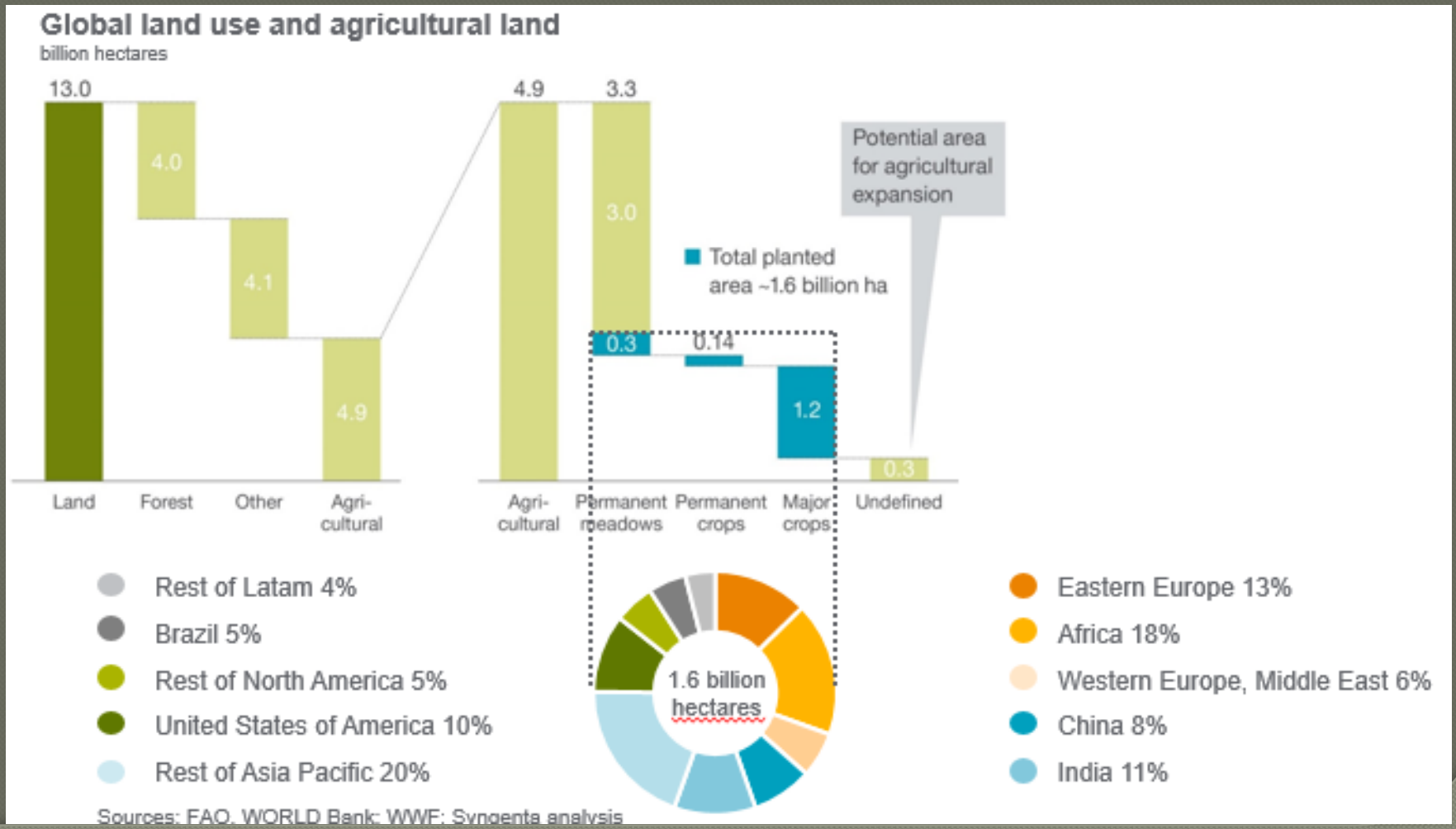
- World Land Use





Limited land for agriculture

- Within the 13 billion hectares of total land, only 1.6 billion is under farmland production (12% of land surface)



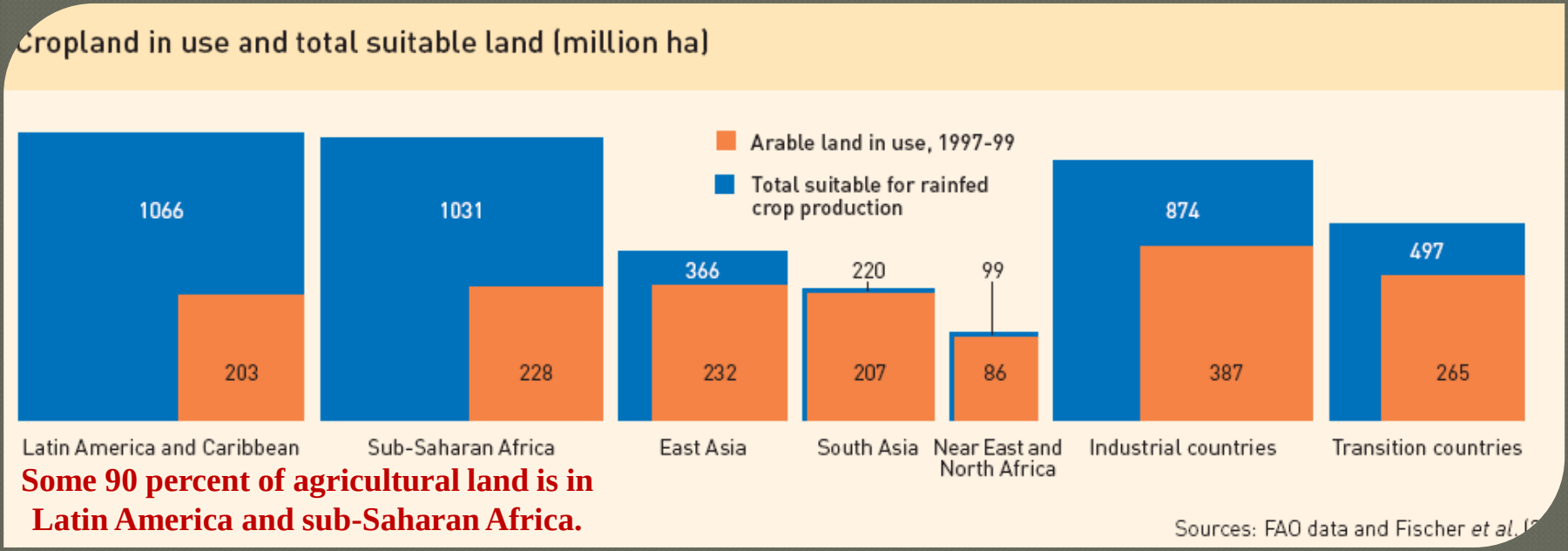
Shortage of Agriculture Land?

the growth rates of world agricultural production and crop yields have slowed

Land Resources

- What regions are running out of their agricultural land?

FACT: To produce the same amount of food today with yield levels from 50 years ago it would require additional land equivalent in size to the USA



- Some 90% of agricultural land is in Latin America and sub-Saharan Africa.
- There is almost none available for agricultural expansion in Southern Asia, the Western Asia and Northern Africa.

CHART 60: **Arable land per capita, top 20 countries (2012)**

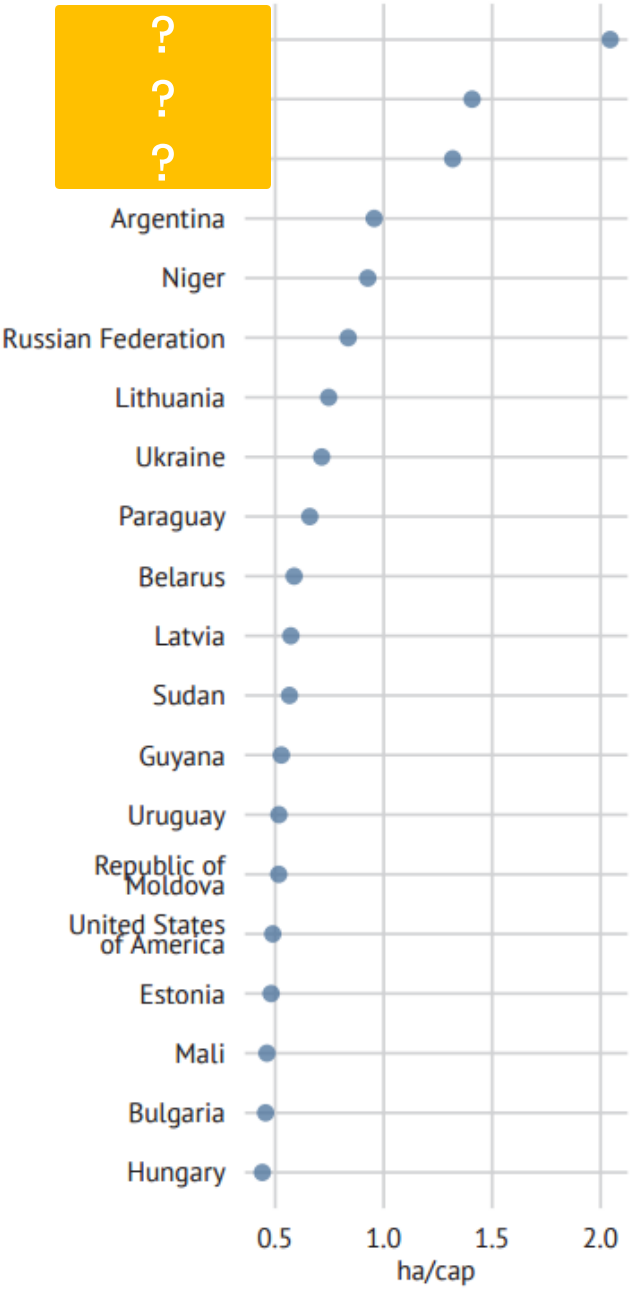
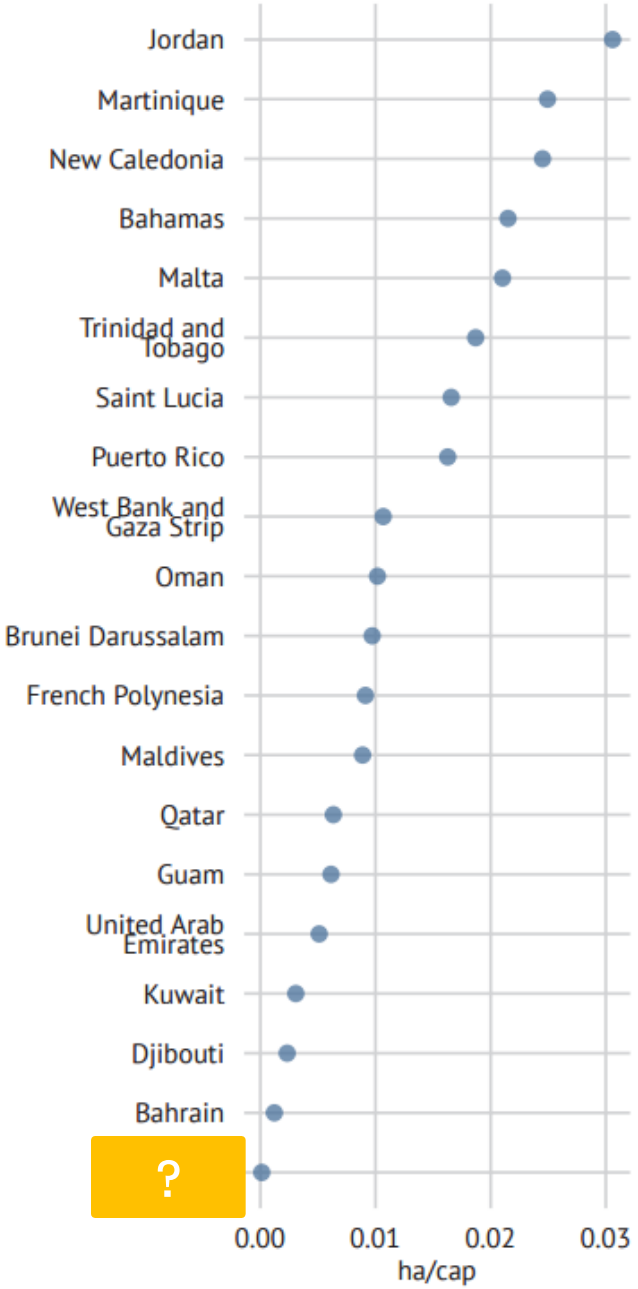
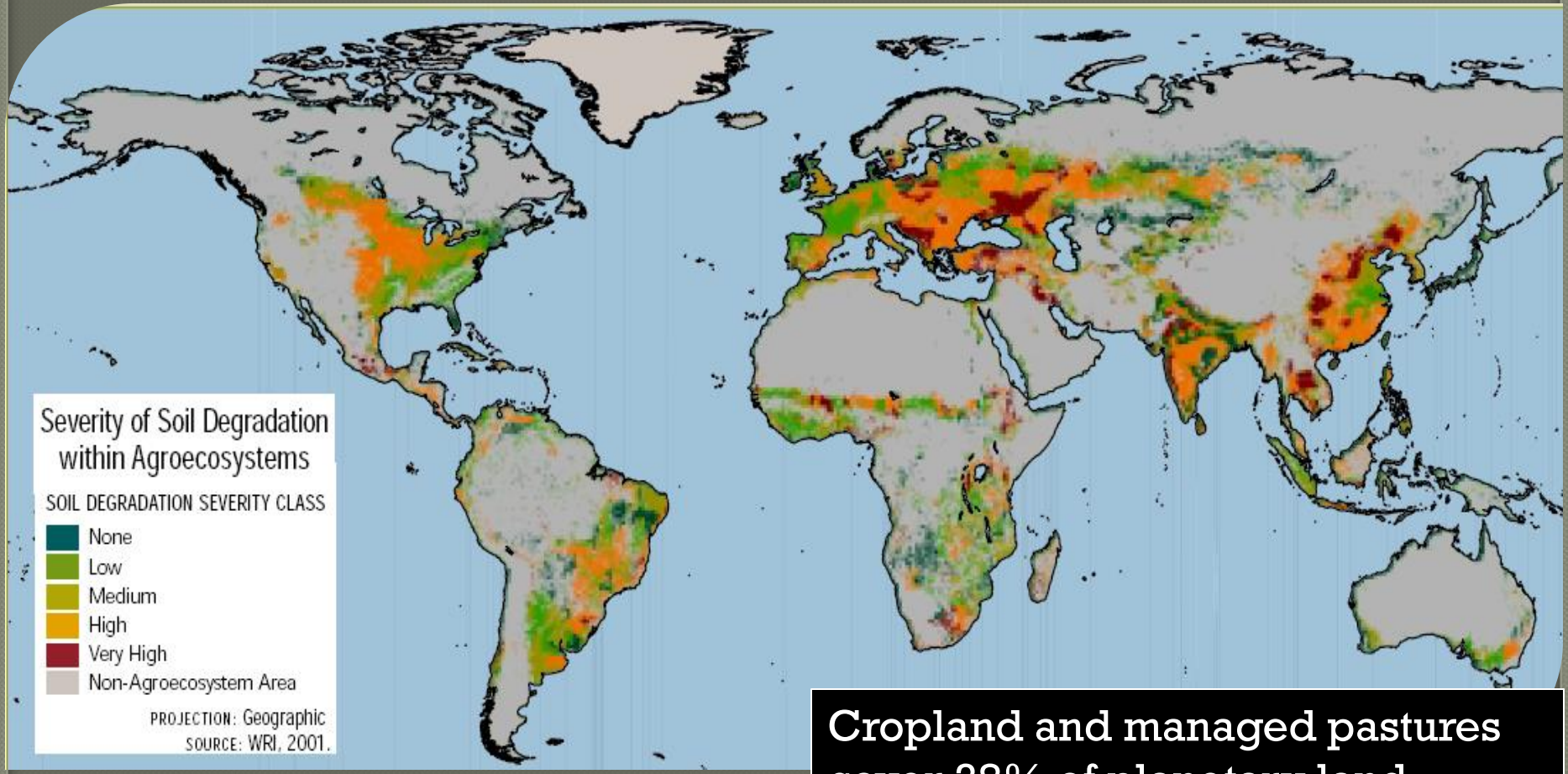


CHART 61: **Arable land per capita, bottom 20 countries (2012)**



Source: FAO Statistical Pocketbook 2015

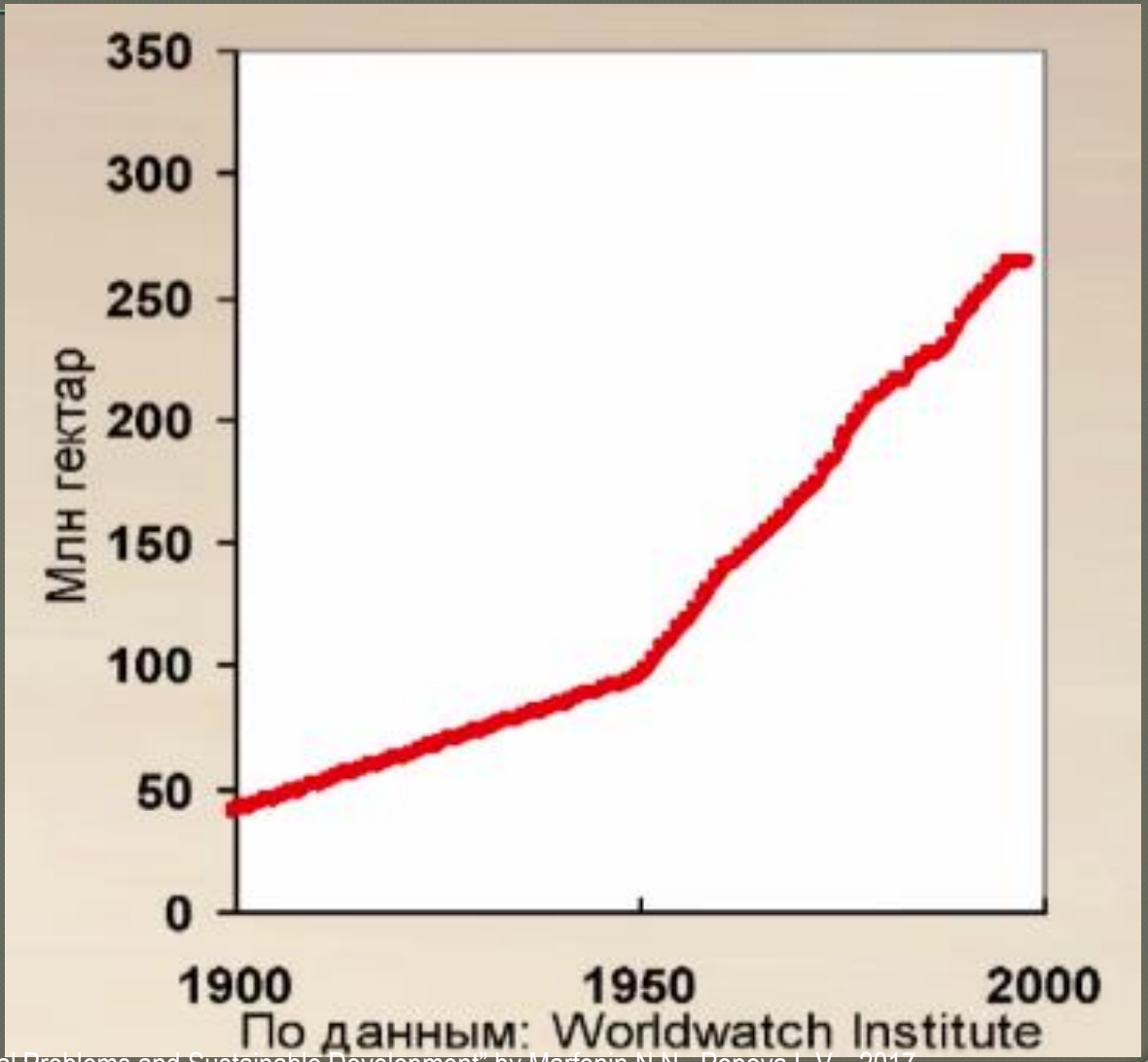
Agriculture Land



Cropland and managed pastures cover 38% of planetary land surface, of which 1/3 is crops and 2/3 - pasture

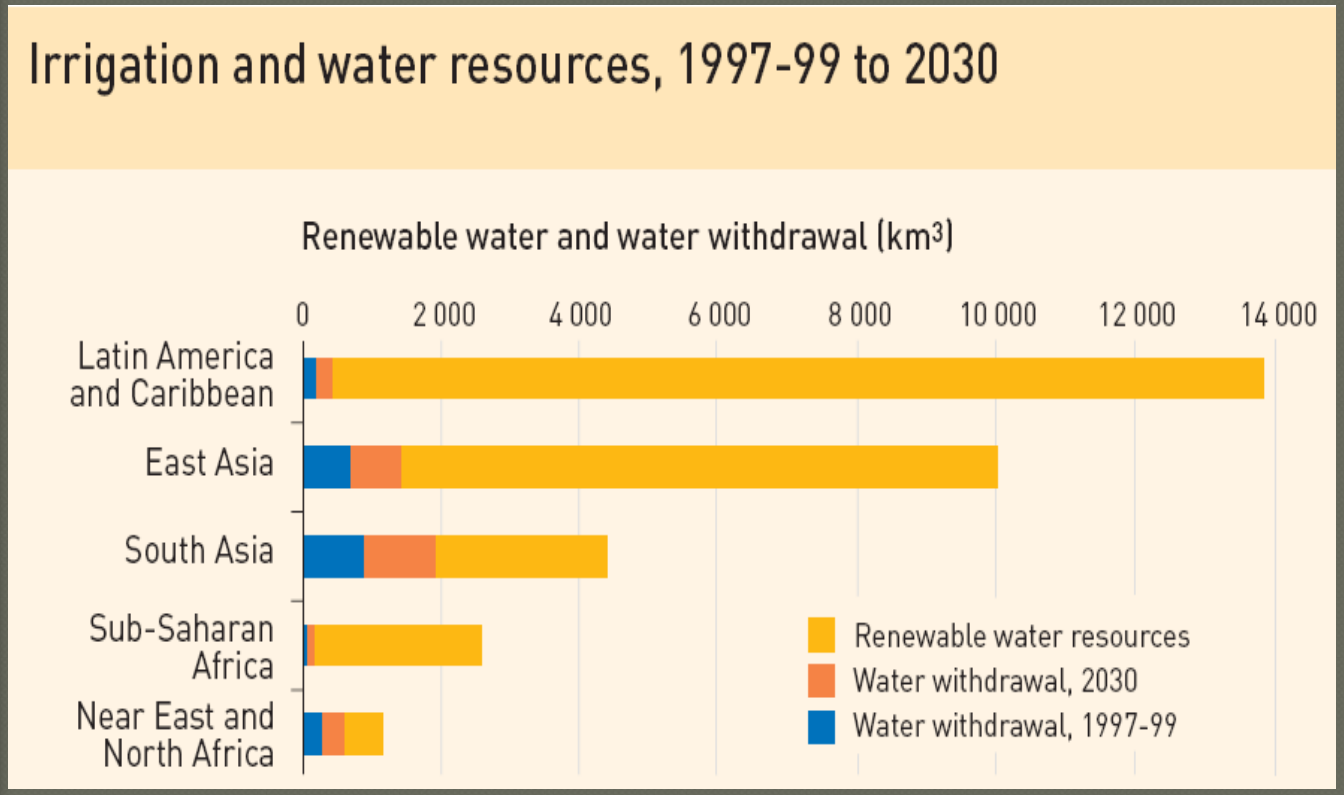
2. Water

- Dynamics of Irrigated Land (1900-1998)



Water

- Irrigation is crucial to the world's food supplies



- The developing countries are likely to expand their irrigated area
- Water resources will be a major factor constraining expansion in South Asia and in Africa

CHART 65: **Freshwater withdrawal by agricultural sector, share of total, highest 20 (1999 to 2013)**

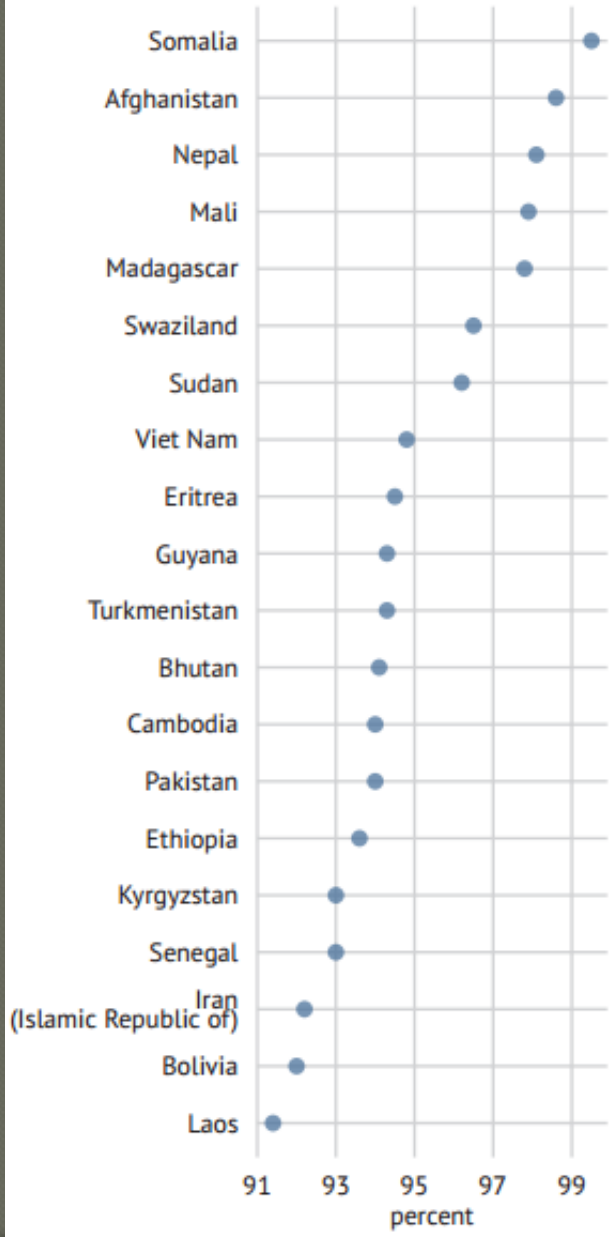


CHART 66: **Countries with the highest renewable water resources per capita**

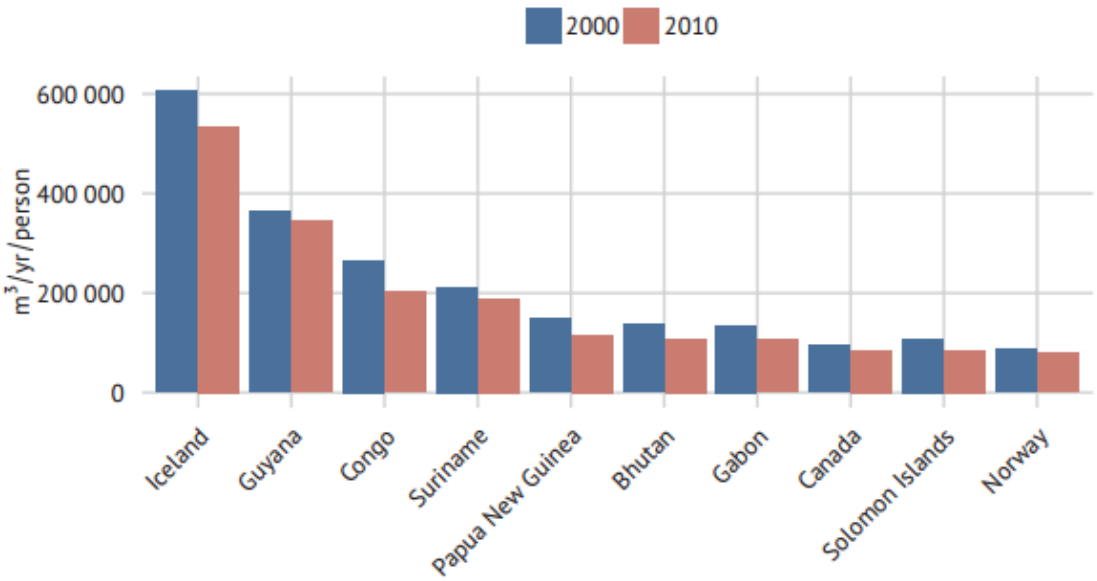
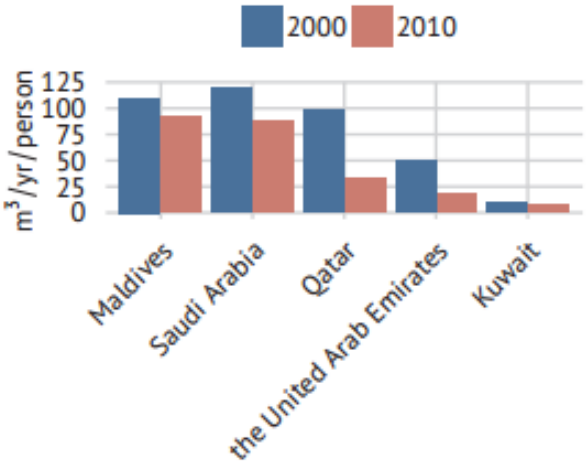


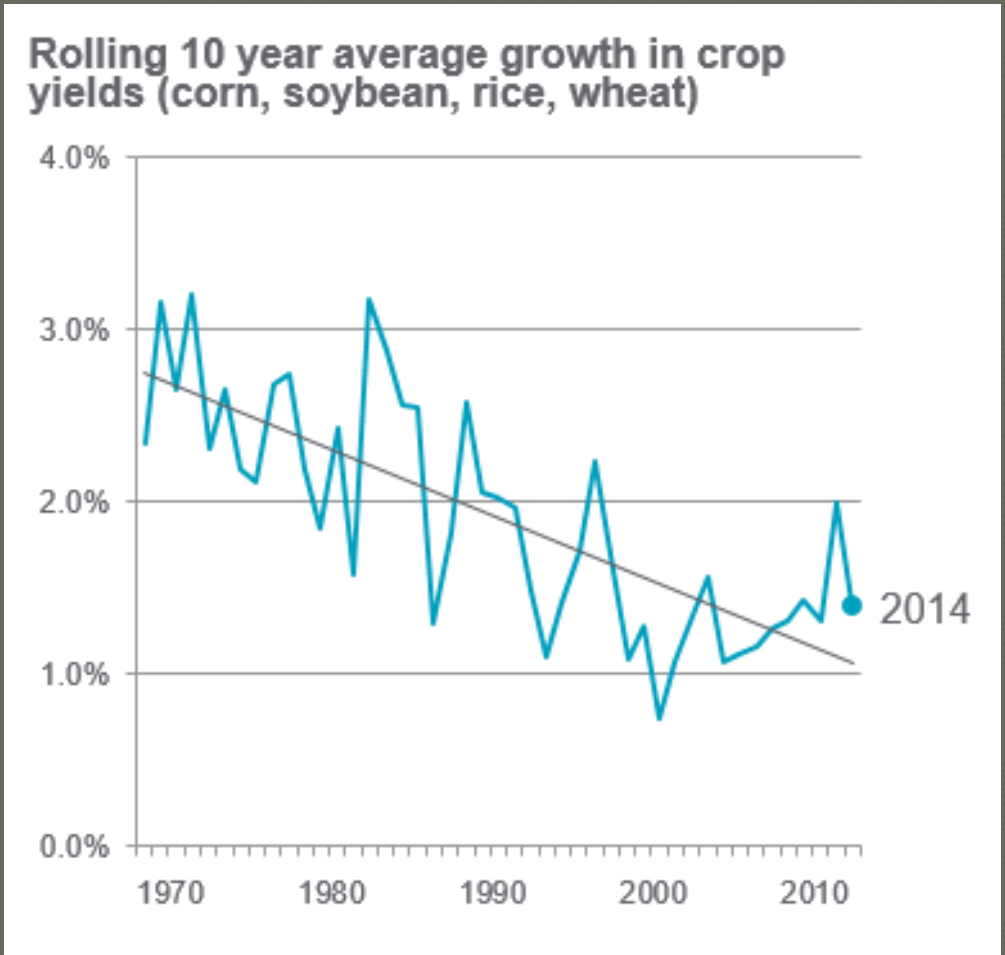
CHART 63: **Countries with the lowest renewable water resources per capita**



3. Yields

- Yield growth will continue to be the dominant factor underlying increases in crop production in the future
  - FERTILIZERS
  - PESTICIDES
  - MECHANIZATION

Yield improvement slowing down in major crops

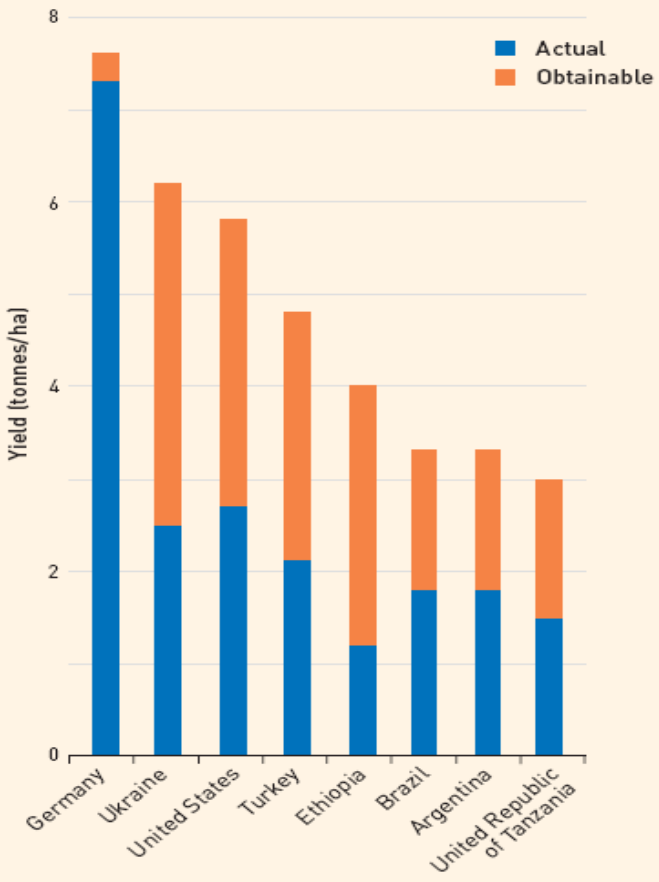


- Reduced yield improvement rate is insufficient to support increasing demand

Source: Syngenta Corporate Presentation, 2017

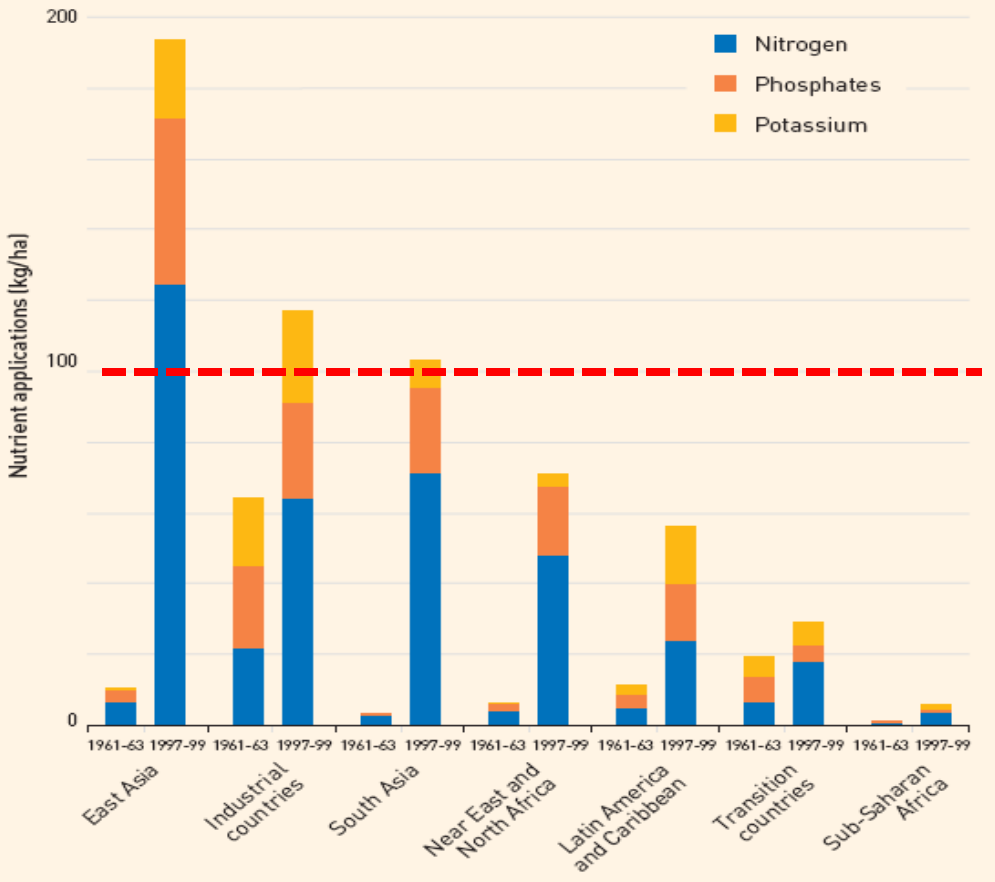
What yield growth is possible?

Exploitable yield gaps for wheat: actual versus obtainable yield



Sources: FAO data and Fischer *et al.* (2000)

Fertilizer use, 1961 to 1999



Source: FAO data

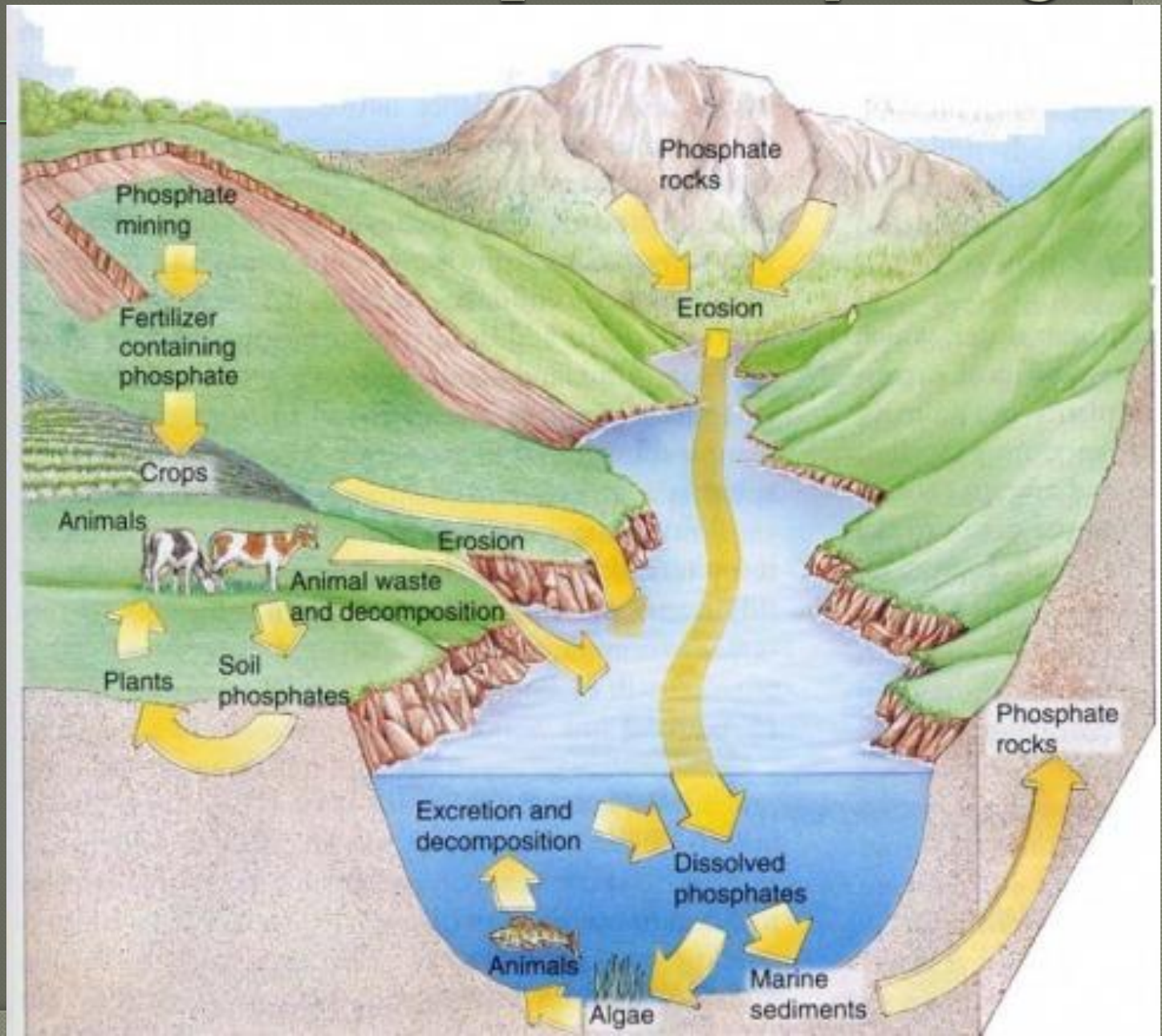
Main Components of Mineral Fertilizers

World	1990	2000	2014
Fertilizers, Nitrogen (kg of nutrients per ha)		*64.9*	*85.8*
Fertilizers, Phosphate (kg of nutrients per ha)		*25.9*	*33.2*
Fertilizers, Potash (kg nutrients per ha)		*18.2*	*20.4*

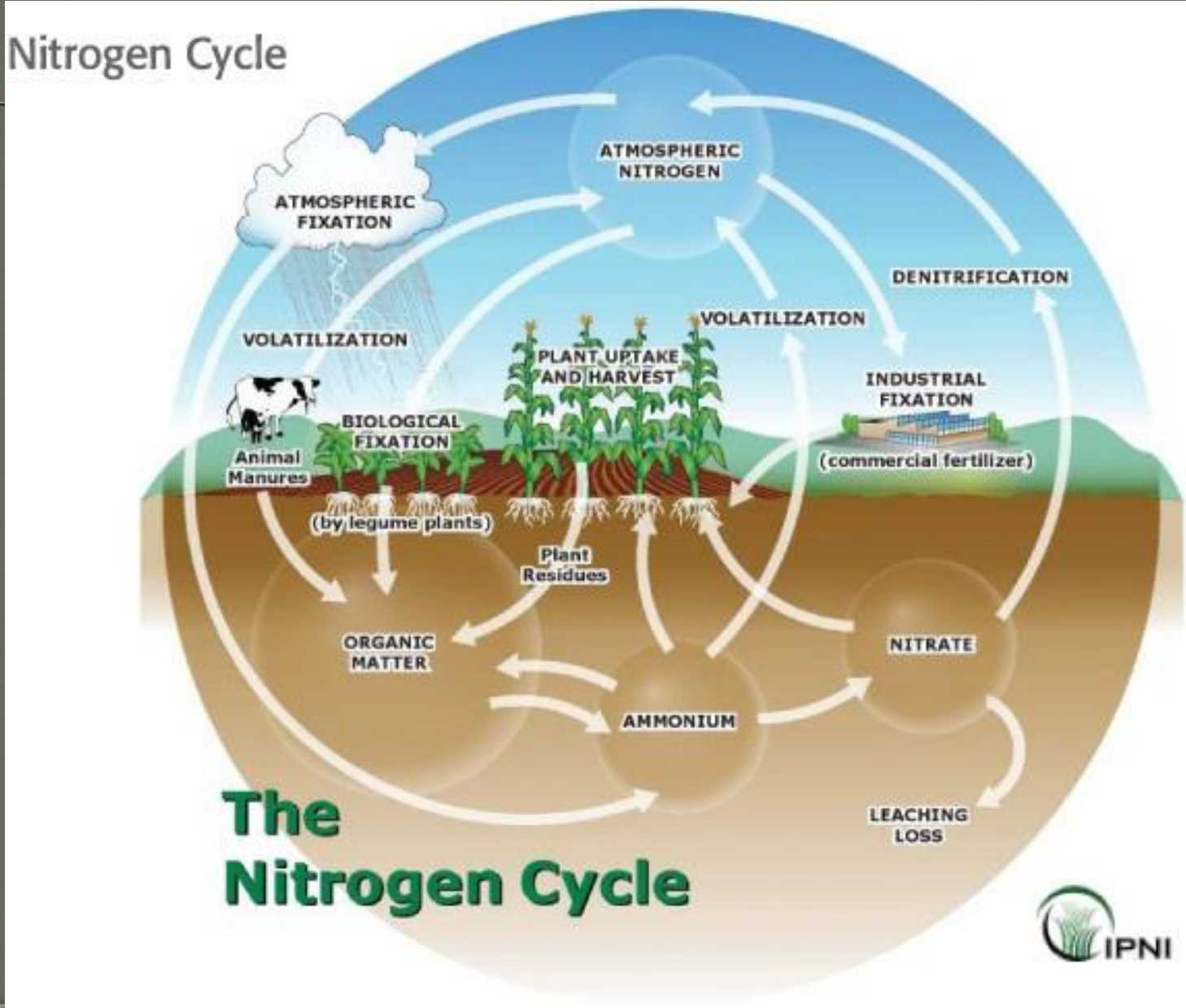
Source: FAO Statistical Pocketbook 2015

- Overuse of mineral fertilizers:
  - Intoxication due to nitrates excess
  - Carcinogenic risk
  - Eutrophication of water
  - Pollution of soils by contaminants

Phosphate Cycling

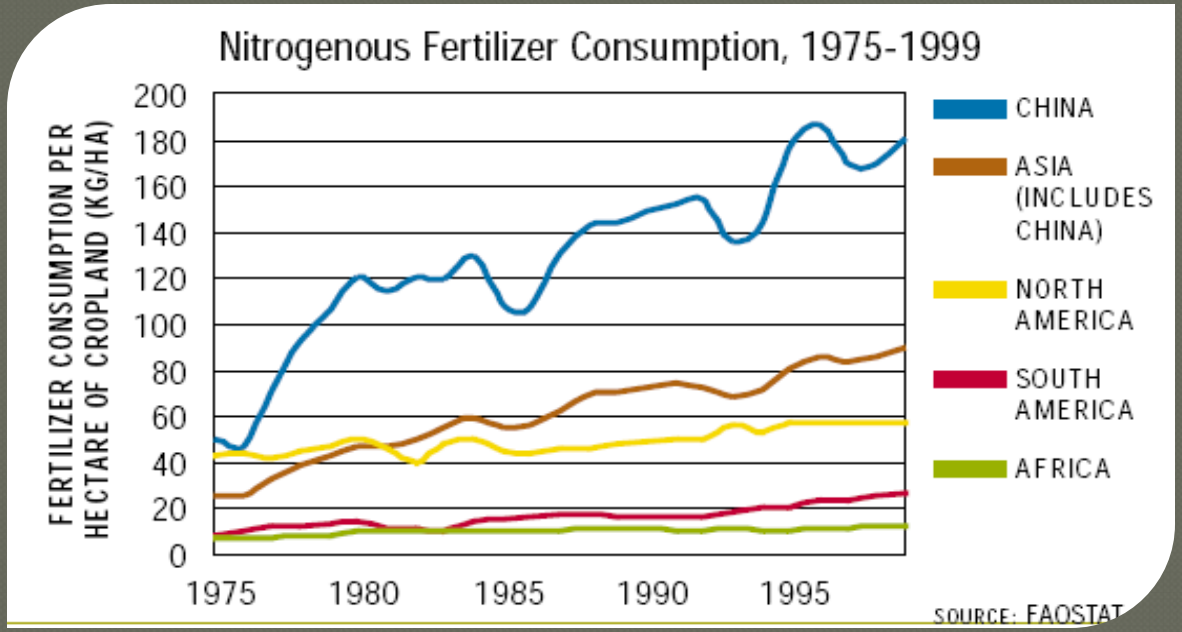


Nitrogen Cycling



Fertilizers in Agriculture

Nitrogen fertilizers and irrigation are being used more and more to raise and maintain crop yields

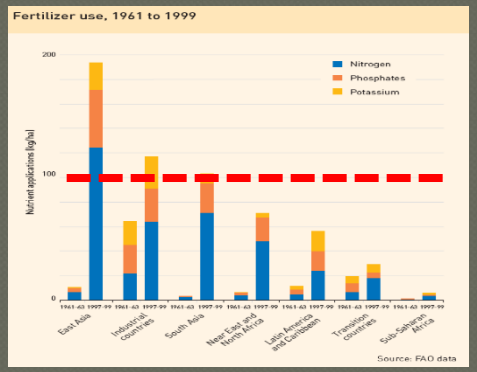


The Monsanto Company

- A US based multinational agricultural biotechnology corporation
- The world's leading producer of the herbicide glyphosate
- The leading producer of genetically engineered (GE) seeds
- Negative case of overuse of fertilizers

Mineral Fertilizers: FACTS

- Nitrates *(нитраты)* → … in human body …→ Nitrites *(нитриты)* → Methemoglobinemia *(метгемоглобинемия)*



Allowable application doses of mineral fertilizers in 1970s**:**

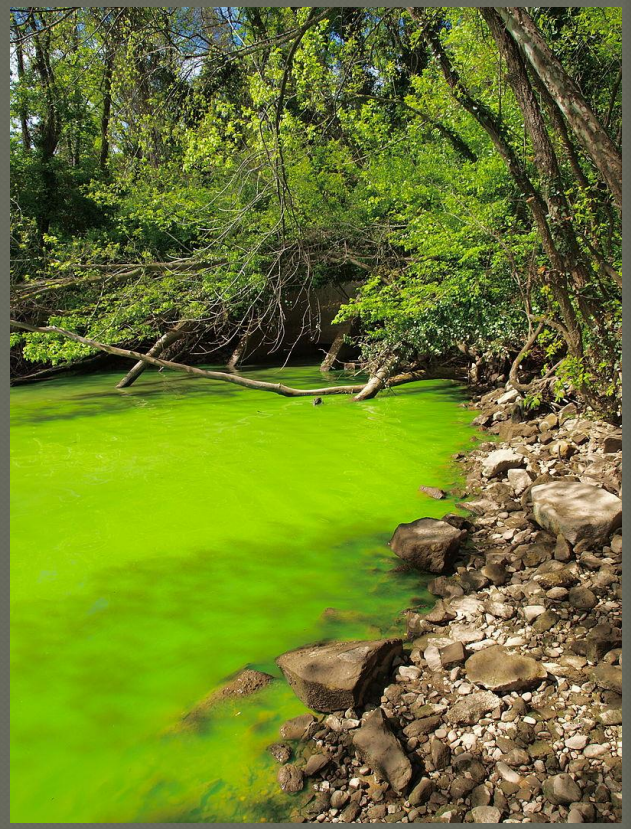
- Western Europe: > **than 100 kg/ha**
- Netherlands: 700 kg/ha
- New Zealand: > than 1000 kg/ha
- USA & USSR: **< than 100 kg/ha**

Consequences of Green Revolution

Nauru Island
in Pacific Ocean:
10 m layer of
Phosphorites

Consequences of Green Revolution

- **Eutrophication** is the enrichment of a water body with nutrients, usually with an excess amount of them.
- This process induces growth of plants and algae and due to the biomass load, may result in oxygen depletion of the water body.



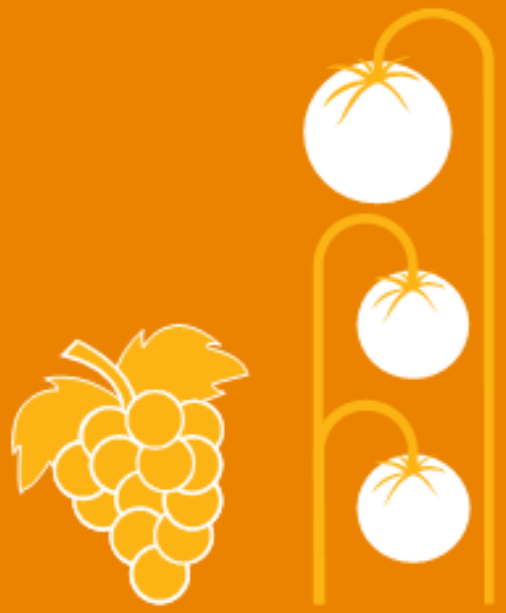
The eutrophication of the Potomac River

Consequences of Green Revolution

- Eutrophication is almost always induced by the discharge of **phosphate** containing detergents, **fertilizers**, or sewage, into an aquatic system.

Consequences of Green Revolution

- PESTICIDES
- **Pesticides** are chemical substances that are meant to control pests or weeds.
- TYPES: herbicide, insecticide, insect growth regulator, nematicide, molluscicide, hermiticide, pesticides, avicide, rodenticide, predacide, bactericide, insect repellent, animal repellent, antimicrobial, fungicide, disinfectant (a ntimicrobial), and sanitizer.
- The most common of these are **herbicides** which account for approximately 80% of all pesticide use.



Without fungicides, yields of most fruits and vegetables would fall by 50–90%, making fresh produce unaffordable to many

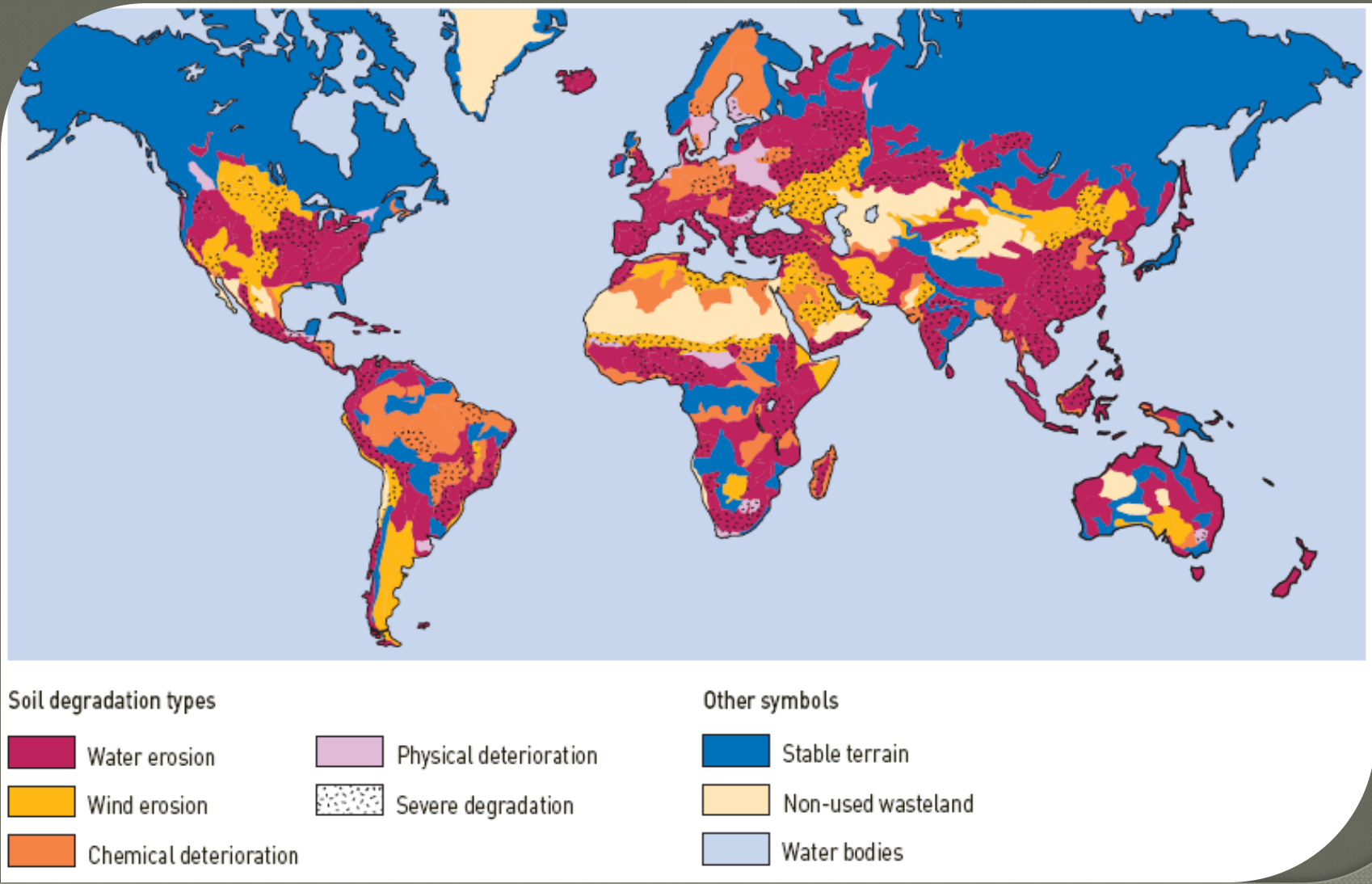
Consequences of MECHANIZATION

- Soil erosion
- Soil compaction
- Increase in energy consumption

Due to drought and desertification each year 12 million hectares of soil are lost (23 hectares/minute!), where 20 million tons of grain could have been grown

syngenta

Human Induced Soil Degradation in the World



No-Till Agriculture *(video)*

- No-tillage is a system of farming in which planting is done in a narrow trench, without tillage, and weeds are controlled with herbicide

- What are main advantages and disadvantages of no-till farming?
- In what countries this method of farming is becoming more popular?